DISCOVERY

Monthly Notebook

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The British Association at Dundee

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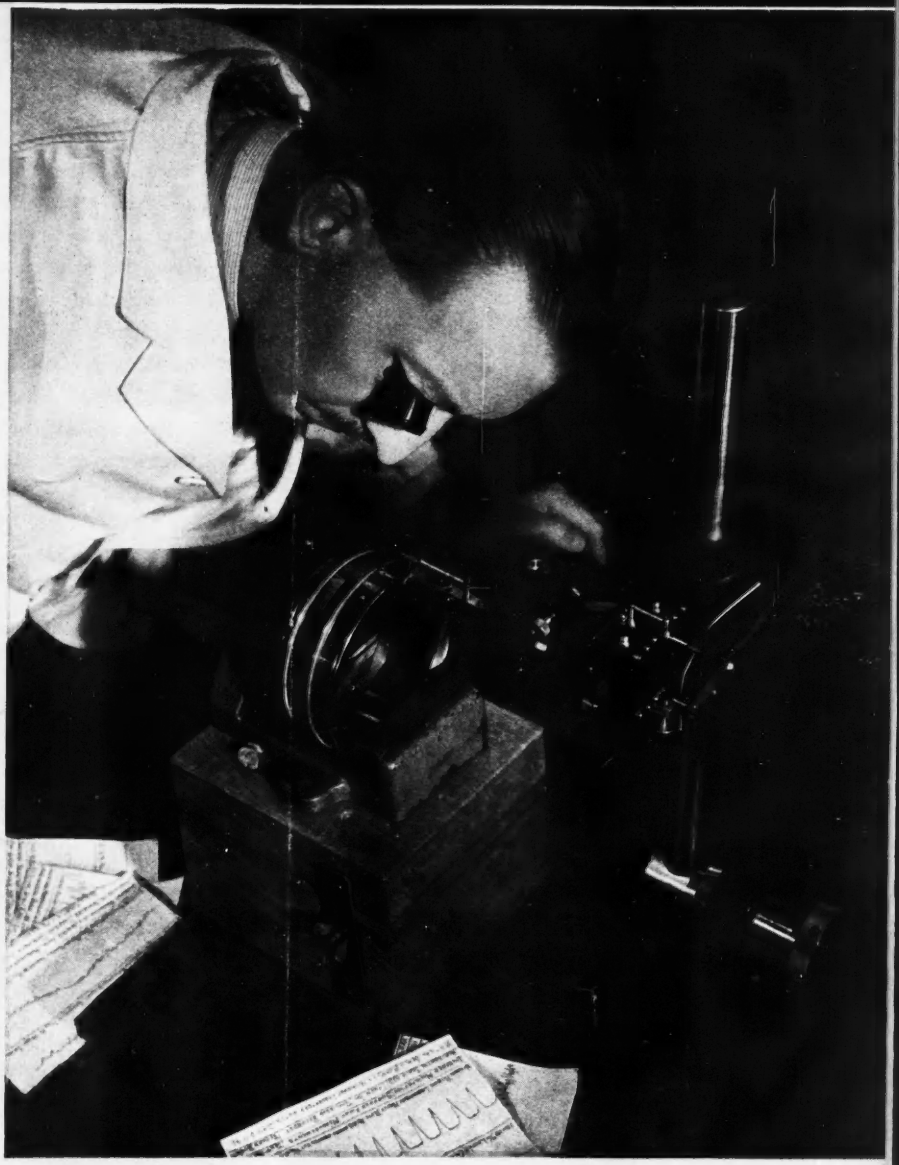

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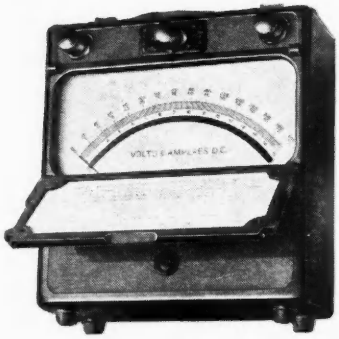

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DISCOVERY

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The Progress of Science

Swords or Ploughshares?

For its Dundee meeting the British Association took as the theme of its deliberations the slogan "Swords into Ploughshares". Judging by the Report of the Select Committee on Estimates on *Expenditure on Research and Development* (an analysis of which was given on p. 286 of our last issue), the slogan is very timely—not so much as a phrase summarising the current trend, but rather as a call to action. For that report reveals that £50 million or nearly two-thirds of our Government research expenditure for 1947–8 is to go into defence research and development. In point of fact, the two-thirds is somewhat of an underestimate; for the Committee included in its total the whole of the scientific part of the Universities grant, most of which is actually devoted to training rather than research. The correct figure would be over 70%.

The Committee posed the question "whether the expenditure of nearly two-thirds of the total sum on defence research represents an equitable distribution between civil and military needs", but gave no answer. The foreign policy questions which lie behind this enormous military expenditure are naturally outside our scope here. But the matter has to be viewed in terms of the recently developed economic crisis. We have to find ways of closing a gap of about £700 million a year in our overseas trade balance. Cuts and sacrifices will help, but the only real solution lies in an enormous expansion of our exports. The possibility of such an expansion is bound up with the rate at which we can increase our industrial efficiency, and that in turn depends largely on the quantity and quality of our industrial research. Yet we are to spend in 1947–8 only £16 million of Government funds on industrial research, as compared with three times that amount on defence research and development.

Our agricultural output is to be increased by £100 million a year by 1951–2—a 20% increase over the output for the year which is drawing to an end. But the extent to which science is to be allowed to help is measured by the estimate of just over £2 million for research on agriculture and fisheries.

We are to increase as far as possible our buying from the Empire, and the enormous undeveloped potentialities of our colonies are now a by-word. But only half a million pounds is to be devoted to the research that would help develop them.

Disease and less tangible debilities are among the chief causes of absenteeism and the chief enemies of industrial efficiency. Yet our state expenditure on medical research is to be just over £700,000 (with another £2 million of the universities grant devoted to medical and dental education).

The Barlow Committee made it abundantly clear that our greatest scientific need is for a drastic increase in the output of trained man-power. Yet the total grant to the universities for scientific, technological, agricultural, medical and dental education and research is to be under £7½ million (of which nearly £2 million represents capital expenditure). On this aspect the Select Committee says, somewhat apologetically, that "the evidence suggests that the allocation for the current year is probably as much as can be usefully and economically absorbed, bearing in mind the severe difficulties in the way of providing new accommodation". But there is at least some evidence to the contrary. The Financial Board of Cambridge University, for example, has recently declared that its Treasury Grant will not be sufficient to meet the needs of the immediate future. Doubtless this is not the only university that will find itself financially cramped.

So the account for Government expenditure reads: £20 million for all constructive aspects of science, both education and research; £50 million for research on how to destroy.

The Barlow Report, which is the nearest thing we have had yet to a strategic plan for British science, was very clear on the matter of priorities—first, teaching and fundamental research; second, civil science, both Government and industrial; third, defence science. When the Report was written over a year ago our economic problems could be foreseen only in a general way. Their transformation into hard facts in August merely serves to make much more clear the justness of the recommendations in the Report. Yet the estimates show that in practice the order

of priority is almost exactly reversed. It is perhaps difficult to say from the figures whether education and fundamental science or civil science is being given second place; but there is no doubt that military research is being given far and away the first.

Road Research in America

Most of us are duly impressed by complicated and elegant fly-over road crossings like that in Fig. 2. Probably very few realise the immense amount of systematic research that precedes their construction—not so much the familiar engineering research, but rather the operational research on traffic flow, causes of accidents and the like, which is required in order to determine just what problems the crossing has to solve. This particular example is from Portland, Oregon, U.S.A., where an elaborate organisation is devoted to discovering and rectifying the causes of road accidents. About 40 police officers are employed full time on compiling the primary facts. They investigate all major accidents and fill out carefully designed questionnaires giving all the relevant information. The drivers involved also make reports, which are strictly confidential and not available to the courts or anyone concerned with them, so that these can be regarded as moderately reliable. Both sets of the reports are sent to the department concerned with enforcement of traffic regulations, where they are coded on punch-cards. From the statistical results so obtained, changes in enforcement measures are worked out—for example, statistics may prove that special crops of accidents arise from speeding in certain areas at particular times, and then new arrangements are made for patrolling those roads.

Meanwhile the reports are sent to the traffic engineering department, where they are again coded on punch-cards, this time from the traffic engineer's point of view. The statistics reveal weak points in road design and measures are taken to correct them. At the junction in Fig. 2, in its original state some 50 major accidents occurred per year. The first corrective measure was to fit traffic signals, and the number of accidents was reduced to 35 annually, their severity being halved. That was not considered good enough, and so the crossing was completely reconstructed to the design shown in the illustration at a cost of 380,000 dollars. And the accidents fell to eight a year.

Fig. 1. This reflector sign indicates what is the safe speed for travelling round the curve.

This example is taken from *Impressions of Roads and Road Research in North America*, by W. H. Glanville and F. N. Sparkes, a report recently published by the Road Research Laboratory of the Department of Scientific and Industrial Research. The general impression that one gathers from this document is that on the purely engineering side (investigation of materials, constructional methods and the like) American research is not greatly superior to our own—except in so far as it benefits from being done on a larger scale and receiving greater financial backing—but that in the more operational research on traffic flow, sources of accidents, human capabilities and failings, and so on, their methods are far in advance.

The typical American attitude seems to be "Roads are made for man, not man for the roads". And accordingly, there is much less tendency to try to adapt the human element to an ill-constructed road system by means of a series of regulations, traffic signs and so on, and more effort is put into the attempt to discover what the real needs are and design the roads accordingly. Surveys are made to discover just where the traffic goes or wants to go and at what speeds. The methods used include interviewing drivers at selected points, use of automatic traffic counters, and house-to-house surveys in which the movements of a sample of the population are statistically examined in terms of destination and route, taking into account journeys in private cars, in public vehicles and on foot. These surveys give a real factual basis for the design of new road systems, by-passes, high-speed through roads, and so on. Apart from data relating to the problems of particular towns or districts, some interesting generalisations have emerged. For example, it is found that the amount of traffic passing through a town which has reason actually to go into the town increases rapidly with the size of the town concerned. For towns with populations of less than 2,500 more than 60% of the traffic is merely passing through. By the time we get to towns of 25–50,000 this percentage is reduced to about thirty. And for cities of 500,000 to a million inhabitants, only about 8% of the traffic could avoid the city—the rest has business within it. Thus by-pass roads are of little value for large towns and the major traffic problem has to be tackled by the construction of through roads having only a limited number of points of access to the ordinary system of city streets.

Studies are also made of the way in which drivers behave in relation to road conditions, of the speeds which are desirable in various types of country—an adopted standard is 70 miles an hour in flat country, 60 in rolling country, 50 in mountainous country and in towns—of the amount of permissible curvature to make these speeds safe, of the reduction of speed necessitated by shorter curves (which in many parts is indicated by road-side signs and a special line marking on the road, Fig. 1), and of a wide variety of similar data. Of course, many of the roads fall short of the requirements indicated by these researches, but at least the standards are known to which new roads should conform.

One of the most interesting trends is the development of a system of highway economics. Largely as the result of the work of Professor Winfrey of Iowa State College, it

FIG. 2.—Plan of fly-over crossing in Portland, Oregon.

is now possible to estimate the social value of a road—in terms of such factors as time and fuel saved, deaths, injuries and property damage avoided, these being balanced against the cost of constructing and maintaining the road, its rate of depreciation, etc. Road authorities can now speak of a road as paying for itself in so many years—10 or 20 years is the period usually aimed at. Needless to say major projects can be undertaken with far greater confidence when their value can thus be estimated.

The financial resources behind this work are, by our standards, colossal. Taking in all forms of road research, the Federal Government contributes nearly £2 million a year, the States provide about the same amount, and further support comes from a number of other bodies. The work is carried out by a wide variety of organisations—government, local authorities, industrial research associations, universities, and many others. Besides their research contribution, three of the universities—New York, Yale and the North-Western University near Chicago—run special educational courses concerned with road safety, either as part of more general university courses, or as short courses, for specially selected candidates from police forces and road authorities. New York specialises in the educational side of road safety, Yale in the engineering aspects, and the North-Western University in problems of enforcement of traffic regulations.

Lest it should be thought that U.S.A. is an unblemished motorist's paradise, let us end by noting that the authors of this report are very critical of the use of traffic signals in that country. These vary from State to State and district to district so rapidly that it is often very difficult to recognise them. Road signs are equally variable and sometimes of very poor legibility. Clearly the Americans could learn much from our excellent system of standardisation in these things.

Synthetic Margarine—Fact and Fable

ASSESSMENTS of German wartime science by different observers have led to widely varying conclusions. One has heard the work of German scientists and technologists described as uninspired though systematic; other reports give a picture of vigorous, resourceful inventors and discoverers. Reports on their work on chemical substitutes, and particularly on synthetic fats, usually fall into the latter category, but with the publication of the BIOS Reports—in particular Nos. 86, 274 and 805—it becomes possible to disentangle fact from fable so far as claims about synthetic margarine are concerned.

Margarine consists essentially of an emulsion of water or skim milk and fats and oils. The particular blend used depends on market conditions. Many of the oils and fats used may be hardened by hydrogenation to alter the texture and melting-point of the resultant margarine.

Synthesis originally meant the building up of compounds from their elements, but now more often covers the building of complex molecules from simple. Fats *have* been synthesised from their elements carbon, hydrogen and oxygen, but this has never been even remotely practicable as a larger scale process. On the other hand, synthesis of fats from simple compounds has been operated in Germany (see DISCOVERY, April 1946).

At the Deutsche Fettsäure-Werke at Witten hard coke was 'gasified' with steam in normal water-gas generators, the essential reaction being represented by the equation

$$C + H_2O = CO + H_2.$$

Extra hydrogen was added in order to increase the ratio of hydrogen to carbon monoxide to 2 : 1, and the gas mixture—the synthesis gas—caused to react in the Fischer-Tropsch process. This consists of passing it over a catalyst, maintained at a temperature of 180–200 C., either at atmospheric pressure or at a pressure of ten atmospheres. Catalysts, of course, alter the speed but not the final products of a reaction. In this case a cobalt-thoria catalyst supported on kieselguhr was used to accelerate the reaction. The products of the reaction were mixed hydrocarbons (compounds containing carbon and hydrogen only) with carbon chain lengths varying from 3 to probably 30 carbon atoms per molecule. Separation, by distillation, into various fractions followed. The fraction distilling between

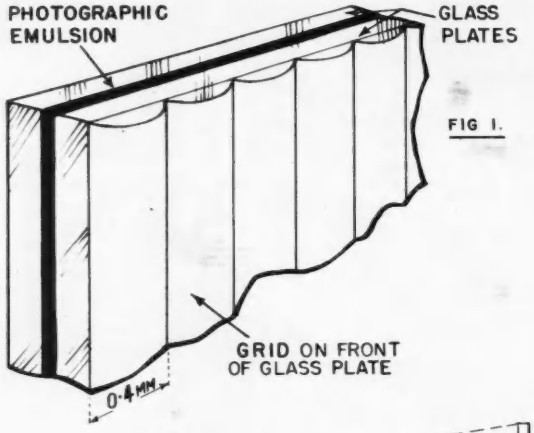


FIG 1.

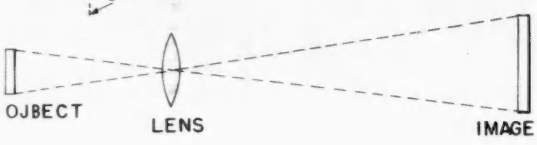
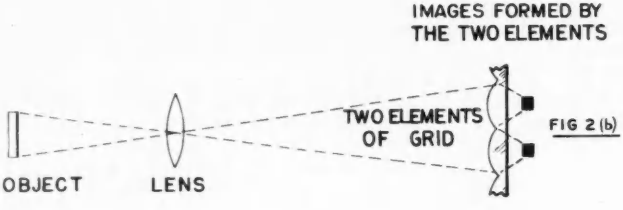


FIG 2 (a)



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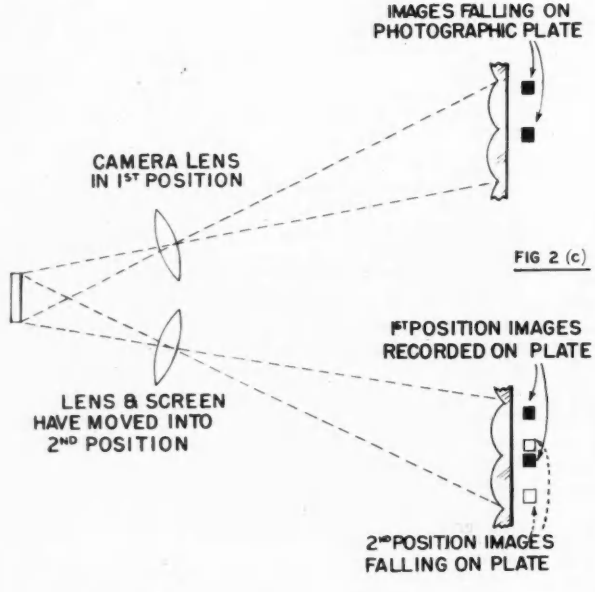

IMAGES FALLING ON PHOTOGRAPHIC PLATE
CAMERA LENS IN 1ST POSITION
1ST POSITION IMAGES RECORDED ON PLATE
LENS & SCREEN HAVE MOVED INTO 2ND POSITION
2ND POSITION IMAGES FALLING ON PLATE

FIG 2 (c)

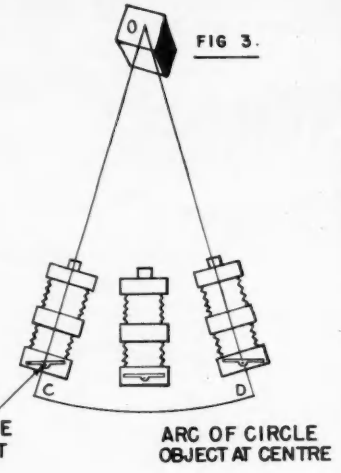


FIG 3.

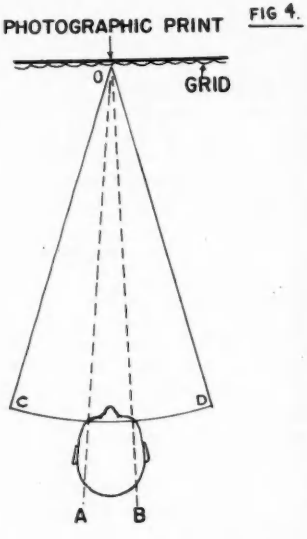


FIG 4.

FIG. 1.—Enlarged section of the plastic grid in position in front of the photographic plate. FIG. 2 (*a*).—Normal system. FIG. 2 (*b*).—Broken image formed by grid. In this diagram the two-dimensional object forms a series of point images; a solid object will produce a series of images perpendicular to the plane of the diagram and parallel to the lines of the grid. FIG. 2 (*c*).—Two broken images formed when the lens and grid are in two different positions relative to the object. FIG. 3.—The camera describes an arc of 32° around the object during the two seconds exposure. At each position a separate set of line images is formed on the plate. The photographic plate and grid remain parallel to their central position throughout the exposure. FIG. 4.—When viewing the finished print the left eye at A sees what the camera saw when pointing along the line AO and the right eye at B sees what the camera saw when pointing along BO. Moving the head from C to D reveals all the aspects of the object seen by the camera between its extreme positions.

320° and 460°C., a soft wax called 'gatsch' was mainly reserved for oxidation to fatty acids and hence for fat production. After purification and fractionation, the acids with chain lengths of between 10 and 18 carbon atoms were combined with glycerine to form the actual fat. This was emulsified with 1–2% of salt, 20% water and small quantities of other additives, to produce margarine. Other fractions were used for soap manufacture.

The margarine was claimed to have exceptionally good keeping properties and hence was reserved mainly for U-boat crews and the Forces in North Africa. Taste was reported to be worse than English margarines, but one observer said grimly that it was "not so bad that hungry people would not have been pleased to eat the fat".

Difficulties arise in assessing the nutritional value of the synthetic margarine, since definite cases were reported where unfavourable results of German investigators had been suppressed by the Nazis. Much discussion ranged about the fact that the fatty acid radicals in natural fats have only even numbers of carbon atoms, whilst those in the synthetic include also the intermediate odd numbers. Experiments on rats tend to indicate that synthetic fat is not so well utilised by the body as natural. There is slightly less digestion of the former and slower body growth, but no definite injurious effects. Insufficient evidence is available to justify any extensive human consumption of these fats.

Of a total of one million metric tons of edible fat consumed in Germany per year, only about 2,000 tons were produced by the above or similar processes at four factories. Hence, contrary to some earlier reports, it never represented any appreciable proportion of the edible fat output.

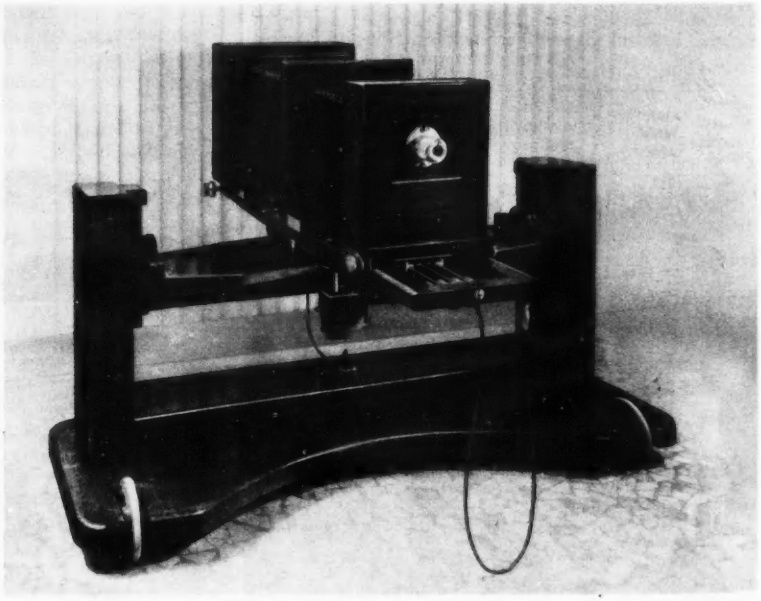


FIG. 5.—The specially designed camera used for taking "Deep Pictures".

Stereoscopy by a New Method

AN interesting new development in the production of stereoscopic pictures has recently been introduced to Britain under the name of "Deep pictures". These are obtained by means of a technique perfected by a French physicist, M. Maurice Bonnet.

All previous attempts to obtain stereoscopic pictures have suffered from two great disadvantages; firstly, some rather clumsy viewing apparatus involving lenses, prisms or colour filters has to be provided for each viewer, and in the second place the view obtained has always been a static one. That is to say, the impression of depth was restricted to that of a person looking at a solid object from one position only; movement of the head from side to side revealed no new aspect of the object. Both of these defects have been overcome by Bonnet's technique. His invention dispenses entirely with individual viewing apparatus and also provides a picture which is 'dynamic' in that one can 'walk round' (albeit through a limited distance) the object portrayed in the 'deep photograph', and thus see much more of it.

To achieve these results the image formed by the normal camera lens is split up into a series of parallel vertical lines by means of a plastic grid placed in contact with the photographic plate (Fig. 1). This happens because the succession of lenses—each of them has the shape of a half cylinder—which are embossed on this plastic grid forms a series of line images on the plate (Fig. 2). When a photograph is being taken, the camera is moved through an arc; for any position through which the camera passes the lens points directly at the object, but the plate remains parallel to the plane of the object (Fig. 3). For each position through which the camera passes a line image is formed by each cylindrical lens at a different place on the plate.

After the plate has been developed and printed in the normal way a plastic grid similar to that used in the camera is placed over the print and this is now viewed from a distance roughly equal to that which separated the object and the camera when the photograph was being taken (Fig. 4). Light reaching the eyes of the observer from the print is refracted by the lenses of the grid in the same way as the light which originally fell on the plate, and each eye sees a different set of line images. The lines however are so close together that one gets the impression of a continuous picture just as the human eye synthesises a continuous picture from the series of lines produced on a television screen.

The possibilities of the invention on the commercial photographic market are obvious. It may also fulfil a useful function both in laboratories and in operating theatres where stereoscopic photographic records would be extremely useful.

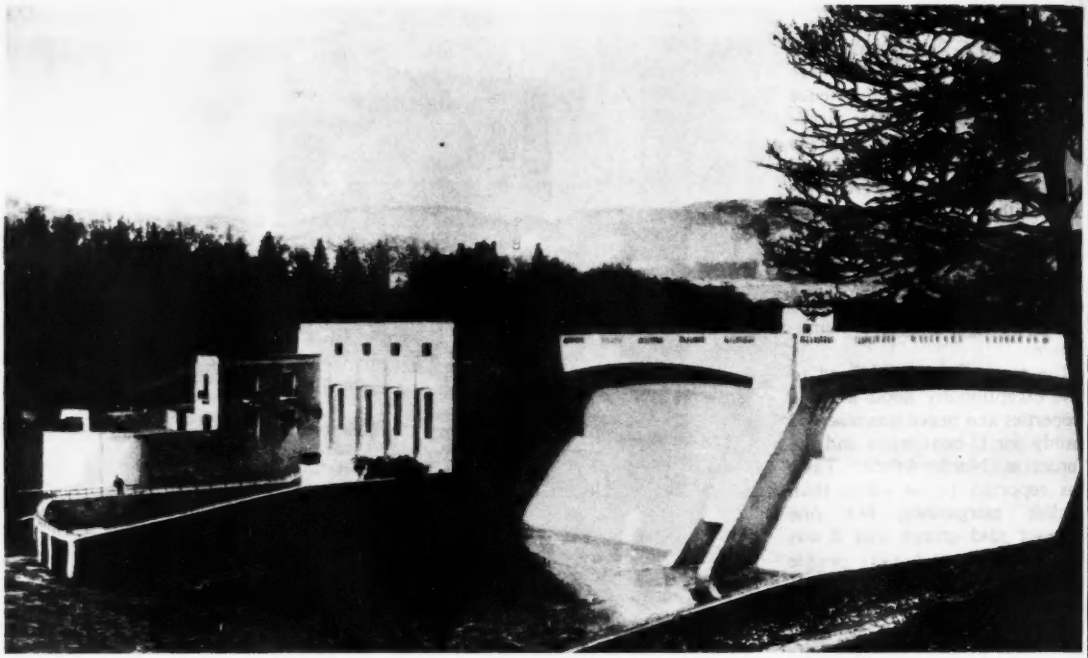


FIG. 1.—A photo-montage giving an impression of how the Pitlochry dam and power-house, which will form part of the Tummel-Garry scheme, will appear when completed. (*Courtesy, North of Scotland Hydro-Electric Board.*)

Hydro-Electric Power in Britain

F. HAMLYN DENNIS, Assoc.I.E.E., F.R.Econ.S.

IN the years immediately ahead it will be necessary to rely mainly on coal-fired stations for the generation of electricity. But, with the acute coal shortage of recent years, more attention has been directed to discover what alternative sources for power production can be utilised. The potential water-power resources which are available for hydro-electric development are not large when measured against national power requirements, but, nevertheless, if all potential water resources were harnessed for power production, they would yield invaluable supplies. There is the great advantage with hydro-electric plant that, when construction is completed, the plant can be operated for several decades with much less labour than is required for steam stations. Furthermore, all electricity generated saves an equivalent quantity of coal that would otherwise be required by steam stations.

The larger part of British water-power resources are in the north of Scotland. The actual potential resources are not known. Official estimates of these always prove to be underestimates. For example, in 1921 potential resources in Scotland were estimated to be 218,000 kW whereas by 1942 this figure had been overtaken and aggregate installed capacity had reached 315,000 kW. These developments were in all cases carried out by private enterprise. The early projects were constructed to supply power for aluminium production. Details of the more important British plants are shown in Table 1. It was not until 1926 that a major plant was constructed for public supply. In 1935 and 1936 the five stations of the Galloway scheme were opened. Under this scheme a contract was entered into between a company and the Central Electricity Board. The company agreed to construct and operate the plants, and the Central Electricity Board agreed to purchase electricity for transmission to industrial centres.

Before the outbreak of war in 1939 various financial interests made several attempts to obtain Parliamentary powers to construct hydro-electric plants with the intention of using them to supply power for electro-chemical processes. These powers were refused through opposition from sporting interests representing fishing and shooting, and through objections on grounds of interference with amenities. It is also interesting to recall that the Association representing mine owners formed an opposition because the development of such projects would tend to shrink the declining market for coal at that time. This was before the coal shortage which has persisted since the war years. As a result of these futile attempts to seek powers for the construction of hydro-electric plants, and the publicity sought by the contending parties, the Government set up a committee to report on the type of authority that should develop water-power resources in Scotland with due regard to the interests of the local population.

This committee, in what has become known as the Cooper Report, recommended in 1942 the creation of a

new public service corporation to be called the North of Scotland Hydro-Electric Board. It was suggested that the Board should be responsible for the development of all further electricity generation for public supply in the Northern Area. One of the recommendations of the committee was that the Board should be bound to give priority to local requirements over all other demands for their power. These recommendations were embodied in the Hydro-Electric Development (Scotland) Act, 1943, and the Board was duly established to be responsible for future developments.

The story of what has taken place since the inception of the Board concerns preparations for the exploitation of available resources. The Board first published an outline of 102 projects to show as far as practicable the resources which it proposed to examine with a view to their possible use for electricity generation. A preliminary list of projects is given in Table 2.

Substantial progress has already been made on works at Sloy, Tummel-Garry, and Fannich, and works at Affric commenced recently. Loch Sloy, in Dumbartonshire, lies to the west of Loch Lomond, and work commenced on this scheme in June, 1945. The area of Loch Sloy will be enlarged and formed into a storage reservoir by means of a dam at the outfall of the loch. The waters impounded will be carried by pipe-line to a generating station at Inveruglas, which will have an annual output of 100 million units from four machines with a total capacity of 130,000 kW operating under a head of 910 ft. One smaller project will impound the waters of Loch Morar, near Maillaig, on the western coast of Inverness-shire, by means of a tilting weir at the outfall of the loch. The generating station, with an initial capacity of 600 kW, will be ready for operation during the summer of 1948. Another station will be built at Nostie Bridge, near the Kyle of Lochalsh on the western coast of Ross and Cromarty, and this station will have an ultimate capacity of 4,000 kW. The estimated cost of these three stations is £4,600,000. The bulk of the output from the Loch Sloy project is intended to meet urgent industrial requirements in Central and Western Scotland, of which Glasgow will receive 105,000 kW. The two smaller projects, like similar projects elsewhere, are designed to supply local requirements in the areas in which they are being carried out. The distribution of electricity in the remote areas of Scotland is not expected to be an economic proposition, and it is planned to subsidise them with profits obtained from larger plants which export to industrial centres.

The Tummel-Garry Project

In Perthshire, the Rivers Tummel and Garry will be harnessed to provide a major scheme with a total output of 300 million units a year. Work commenced on this scheme in January, 1946. There will be a series of three lochs, each supplying water to a separate generating station, to form a co-ordinated chain of three stations, all situated on the River Tummel watershed. The upper loch will be formed by impounding the upper tributaries of the River Garry and the Errochty Water in Glen Errochty. The waters will then be carried by tunnel to the Errochty generating station. This station will house three machines with a total capacity of 75,000 kW, operating under a head of 610 ft. at the western end of Loch Tummel. It will be used to meet peak load demands in the Central Scotland district. (A hydro-electric station has the advantage over a steam-generating plant, when used for peak

TABLE 1

Existing British Hydro Stations where the Installed Capacity exceeds 5,000 kW

	Name of station	*Supply commenced*	*Present installed capacity (kW)*
SCOTLAND:			
British Aluminium Co. ..	Foyers	1896	5,000
British Aluminium Co. ..	Kinlochleven	1909	23,000
British Aluminium Co. ..	Lochaber	1929	83,000
Lanarkshire Hydro E.P. Co.	Bonnington	1926	9,840
Lanarkshire Hydro E.P. Co.	Stonebyres	1926	5,680
Grampian E. Co.	Rannoch	1930	48,000
Grampian E. Co.	Tummel	1933	34,000
Galloway Water Power Co.	Tongland	1935	33,000
Galloway Water Power Co.	Glenlee	1936	25,000
Galloway Water Power Co.	Earlstoun	1936	12,000
Galloway Water Power Co.	Carsfad	1936	12,000
Galloway Water Power Co.	Kendoon	1936	21,000
WALES:			
N. Wales Power Co. ..	Cwm Dyli	1904	6,500
N. Wales Power Co. ..	Dolgarrog	1909	21,700
N. Wales Power Co. ..	Maentwrog	1928	24,000
		Total	363,720

TABLE 2

The Provisional Ten-Year Programme of the North of Scotland Hydro-Electric Board

	Plant Capacity kW (approx.)
Loch Sloy	130,000
Loch Morar	2,000
Lochalsh	4,000
Tummel-Garry	150,000
Gairloch	3,000
Fannich	24,000
Cowal	6,000
Shira	44,000
Affric	60,000
*Duntelchaig	32,000
Skye	2,000
Ullapool and Lochinver	1,000
Quoich	60,000
Lyon	60,000
Giorra	10,000
Lawers	20,000
Lednock Earn	20,000
Foyers	30,000
Glascarnoch	25,000
Luichart	24,000
Tor Achilty	10,000
Orrin	14,000
Straith Farrar Beauly River	60,000
Tarff	20,000
Total	811,000

* This scheme is in abeyance because the Burgh of Inverness require exclusive rights to use Loch Duntelchaig for water supply.

loads, that there are no fires to be kept banked under boilers and no delays are caused by the time required to raise steam. There is almost instant availability in the case of hydro-electric plant.)

A reservoir for the middle station, called Clunie, will be formed by a dam to the east of the existing Loch Tummel, which will raise the level of the Loch by 17 feet. Water from the loch will be taken by a tunnel $1\frac{7}{8}$ miles long, of horseshoe section, to the Clunie station, which will have a capacity of 57,000 kW. The plant will consist of three water turbines driving alternators operating under a head of 170 ft. This station will be closed down at night.

A third dam across the River Tummel at Pitlochry will form a new reservoir into which the Clunie station will discharge its water. This reservoir will act not only as a storage but also as a balancing reservoir to equalise the fluctuating discharge from the Clunie station. The third and lowest station at Pitlochry will have two turbines with a total capacity of 15,000 kW, operating under a head of 54 ft. In this chain of three stations the water supplying the Errochty station will pass through the Clunie station, and the Clunie water will pass through the Pitlochry station. In addition, the waters discharged from the existing generating stations on Loch Rannoch and at Tummel Bridge will be used by the Clunie and Pitlochry stations. The three stations will produce 293 million units a year. The cost of the whole scheme will be £6,450,000.

The Mullardoch-Affric Project

The first large-scale project for the northern part of the Board's area will utilise Loch Fannich, near Inverness in Ross-shire, as a reservoir. In this scheme there is no dam, because the loch has sufficient natural storage capacity. A station will be built at Grudie Bridge in Strath Bran at an estimated cost of £960,000. The station will have an annual output of 80 million units from two machines with a total installed capacity of 24,000 kW. The output from this station will be inter-connected with stations at Tummel-Garry and Aberdeen, so as to form a basis from which the development of the North of Scotland District electricity supply can be built up.

The construction of plants to utilise the water-power resources of the Glen Affric and Glen Cannich areas began in February, 1947, after several years' delay. It is more than 20 years ago that these resources were first investigated. The record of what took place over the intervening years shows the difficulties which had to be swept aside before agreement could be reached to harness such water-power resources as exist. The shape of the opposition which so effectively blocked development has already been discussed and here it will suffice to recall that, in the case of Glen Affric, the first scheme to be promoted by the Grampian Company, in 1928, was rejected by a House of Lords Committee. A second scheme, promoted by the same Company in 1941 was finally withdrawn when the Secretary of State promised an inquiry into the whole question of water power resources in Scotland.

The scheme now under construction includes the creation of a large reservoir, 9 miles long, in Glen Cannich, by raising the level of Loch Mullardoch by 113 feet. A tunnel will divert its waters to Loch Benevean through an underground power station of 4,000 kW capacity. The main power station, near Fasnakyle, will house three sets with a total capacity of 66,000 kW, driven by three turbines operating under a head of 522 feet. The two stations will cost £4,800,000 to build, and together will produce 236 million units a year. This scheme, like others now under construction, has been prepared in such a way as to

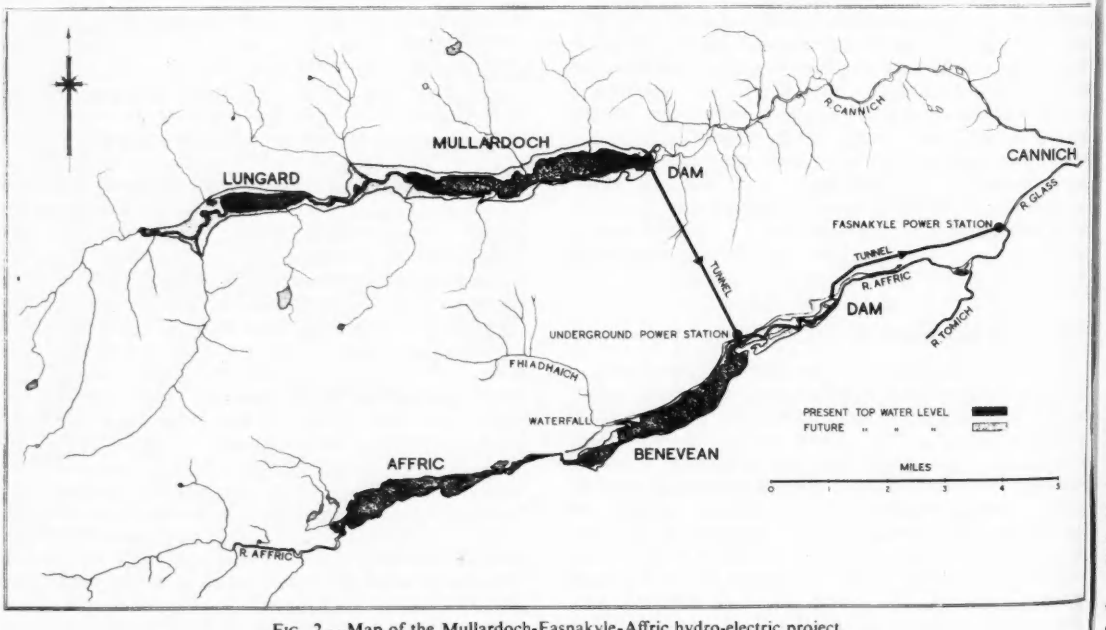


FIG. 2.—Map of the Mullardoch-Fasnakyle-Affric hydro-electric project.

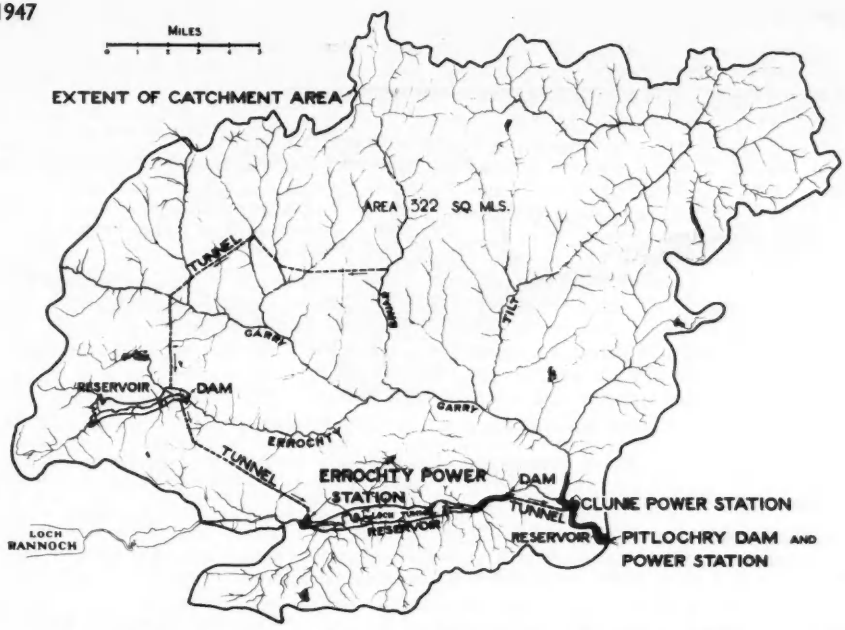


FIG. 3.—Map of the Tummel-Garry hydro-electric project.

minimise interference with local amenities. Provision has been made to give a 'block guarantee' of 2,000 million gallons of water a year from Loch Benevean which will be used at such times as agreed with the Fisheries and Amenity Committees. A minimum flow of water in the River Affric will be guaranteed below its junction with the Tomich Burn, and the levels of the lochans in the Glen will be maintained by small weirs specially erected to preserve the trout.

Other schemes, on which work is expected to commence in the near future, provide for the construction of generating stations in the Shira, Morar, Lochalsh, Cowal and Bute, Skye, Gairloch and Kintyre areas. The Shira scheme, which is the more important, will harness the upper waters of the River Shira and the River Fyne. This scheme will cost £3,150,000, and produce 80 million units a year. Two new lochs will be created in the hills above Loch Fyne. The water discharged from the main storage loch will pass through a small power station of 4,000 kW capacity. It will then pass to a subsidiary loch to be formed in a natural basin 160 ft. below. This loch will also collect water from a lower catchment area and then it will be conveyed 4½ miles by tunnel and pipe-line to the main generating station, of 40,000 kW capacity, situated on the main Arrochar-Inverary road near the head of Loch Fyne, where a bridge will be built to carry the road over the tail-race. The main generating station under this scheme will operate in conjunction with a station of 6,000 kW capacity and 14 million units a year output which is to be constructed at the head of Loch Striven. The plant in this smaller station will consist of two 3,000 kW alternators, direct coupled to turbines which will operate under a head of 394 ft. Water will be supplied from a reservoir in Glen Tarsan.

The present plans for Scotland provide for the delivery of 21 machines with a total capacity of 374,000 kW. It is estimated that the annual output from these plants will approach 720 million units within the next three years and that, within the next ten years, 27 water-power stations with a capacity of 811,000 kW will be in operation. The output from these stations is estimated to be 2,250 million units a year. If this figure is compared with the estimated potential resources in Scotland of 6,274 million units, it may be deduced that, at the rate of construction at present envisaged, thirty years will be required to harness known resources in Scotland alone.

The Severn Barrage Scheme

There are very limited inland water-power resources in England but proposals for generating electricity with tidal plant by the construction of dams across the Severn have been under discussion for many years. As long ago as 1925 the Government appointed a sub-committee to investigate the practicability of a barrage. This committee reported in 1933 that a barrage and power station situated about 2½ miles below the confluence of the Wye and Severn Rivers, near the line of the existing Severn tunnel, known as English Stones, could generate power at only two-thirds of the cost of that generated in coal-fired stations.

A further report by a Panel of Engineers, set up in 1943 to review the conclusions of the former committee in the light of later technical developments, recommended that the generating plant to be installed should have a maximum total output of 800,000 kW at spring tides from 32 turbines coupled to alternators, each with a capacity of 25,000 kW. The annual output of the plant would be 2,107 million units, this being equivalent to the present aggregate annual consumption of Glasgow, Manchester, and Sheffield. Electricity would be generated during two periods of about seven hours each in every 24 hours, on falling tide only, high-water occurring about 48 minutes later each day. Thus, the barrage would only give a varying and intermittent supply of electrical energy, depending on the tides.

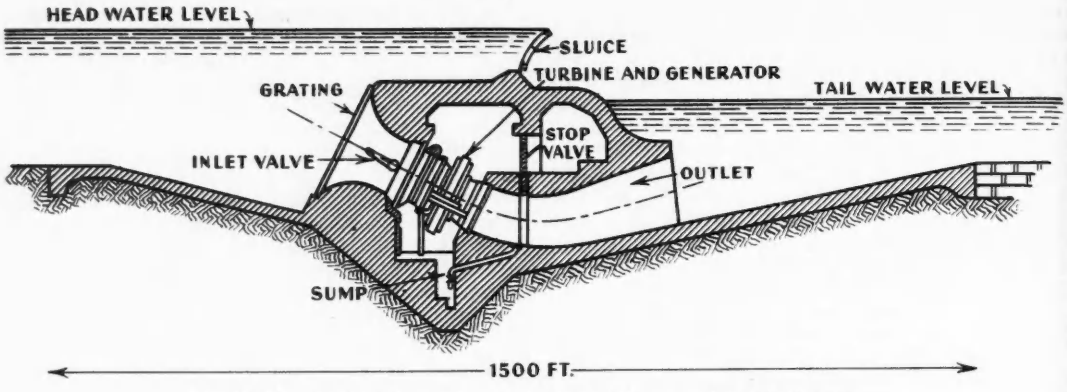


FIG. 4.—Cross-section of an underwater hydro-electric power plant. The Germans were developing this system of power generation, and had one such plant which had been working since 1938.

To obtain a continuous output, it would be necessary to construct a secondary station with a storage reservoir. Without such a secondary storage scheme, it would not be possible to reduce the capacity of coal-fired stations which would be required to eliminate fluctuations from the tidal plant.

In the report of the Panel of Engineers in 1945 the proposal to build a pumped storage system was rejected. The reasons were that it would increase the capital cost of the barrage by 40% and that, in operating the system, 27% of the electricity generated by the barrage would be lost. The engineers recommended that the barrage plant should be operated in parallel with coal-fired stations in such a way as to eliminate the effect of the tides. This aspect requires further investigation in the light of the present fuel position before a final decision is reached.

The cost of the scheme, without the storage system, was estimated to be £47 million (in 1944 prices). According to the first barrage report of 1933, it would take 15 years to complete the work. The 1945 report, however, reduced the construction period to 8 years. By the use of up-to-date machinery for civil engineering works it should be possible to reduce the construction period still further.

The scheme has been opposed by port authorities of the Bristol Channel, not on grounds that it would interfere with trade, but because they fear silting of their ports. Experiments made on a model of the Severn Estuary have shown that a certain amount of silting is likely to take place above the proposed site for the barrage. It was, however, not considered that this would prejudice navigation because a small amount of dredging would maintain the river in its existing condition. One sign of renewed Government interest in the project is that a sum of £40,000 has been allocated recently, by the Ministry of Fuel and Power, for further research into the danger of silting.

With the exception of plans to increase output from existing plants in North Wales by increasing water storage capacity, no decisions have yet been taken to commence work on other schemes such as the Severn or Menai Straits. The present and potential output from hydro-electric plants in Britain may be compared with national power requirements in the following manner. In 1945 there were 44,650 million units generated by steam and hydro stations. Of this amount, 1,330 million units, or 3%, represents output from hydro stations. If the following potential resources are included: Scotland, 6,274, Severn, 2,107, and Menai Straits, 90 million units, the output that may be expected from hydro stations rises to 9,801 million units, representing 22% of national power production in 1945. Thus, it is clear that power requirements must be covered principally by coal-field stations. Hydro stations will only assume a subsidiary role. This in no way minimises the services that can be rendered when our water resources are harnessed. The main factor in hydro schemes at the present time is the possible reduction in coal consumption of four million tons a year which could be attained through their full exploitation.

The construction schemes now in hand will double the present capacity of existing hydro stations within the next three years. To speed up the rate of construction, however, it will be necessary, not only to increase the number of men employed on the various sites, but also to ensure that sufficient labour and materials are made available to expand the capacity for manufacturing generating plant.

In view of the severe fuel crisis which grips Britain, the present high cost of coal, and the growth in demand for electricity, we cannot afford to allow water-power resources to remain untapped. Nor can we base our hopes on a return to cheap and abundant coal supplies for future power production. A proposal by Mr. F. O. Harber, which has not yet received support in official quarters, to turn the Menai Straits in North Wales into two basins, one at high level feeding the other at low level, would have generating plant at the junction flow. The Straits would be dammed at three points. This would divide the Straits into two basins equal in volume. With one topped up at high water and the other drained off on the ebb, there would always be a head of water between the two. It is estimated that this scheme would produce 70 million units a year.

Previous estimates of potential water-power resources have, in all cases, been based on the assumption that

standard types of plant would be installed. If, however, hydro-electric machines of entirely new design were devised, it might become a practical proposition to harness waters that have so far escaped attention. One such method, called 'Unterwasserkraftwerk' or 'underwater power plant', connected with the name of the German engineer, Arno Fischer, can be applied to low head schemes. The term 'underwater power plant' originates from the fact that, during floods or periods when the flow exceeds the amount for which the sluices and the turbines are designed, movable dams are lowered and a sheet of water covers the plant completely. Combined turbo-generator sets are installed in waterways formed through the body of a concrete dam. A turbine of the axial flow type is employed, with the windings of the rotor mounted on the circumference of the turbine runner. Elaborate arrangements are required to prevent water reaching the electrical parts of the set. An automatic, float controlled, tilting gate is mounted on top of the dam which allows surplus water to flow over the station.

The cost of underwater plant is stated to be lower than the cost of orthodox Kaplan plant on account of a reduction in the civil engineering work that is required. Plant of this type is much less conspicuous than any previously designed. It blends completely with the landscape and may actually improve it. An underwater power plant situated on the River Iller, in Bavaria, composed of four machines, each of 2,250 h.p., has been operating since 1938. Another underwater plant on the River Luch, also in Bavaria, has six machines of 1,660 h.p. each. These have been in use since 1945. The operation of these plants is reported to be favourable, although among experts opinion is divided on their future application.* It is, however, of interest to note that Russian engineers are convinced that this new design is of sufficient importance to justify the construction of an underwater station of large size, on the River Kama, a tributary of the Volga. The station is planned to supply the Urals, and it is anticipated that supply will commence in 1950. If it should prove possible to harness tidal waters at various places around the coast of Britain by this method, where it would not be a practical proposition to construct plants of orthodox design, there would be a marked increase in the potentialities of water power.

* See H. W. Hamm. "A Review of the Design of Submerged Hydro-Electric Power Plants." *FIAT Report No.* 1013. H.M.S.O. 1947.

FILMS ABOUT THE ELECTRON

THE less tangible physical concepts associated with the fundamental behaviour of matter and energy do not lend themselves easily to visual portrayal. The lecturer and textbook writer, in explaining ideas involving complex or invisible motion, are often compelled to use logical but laborious chains of argument which may obscure a clear mind-picture of the whole. The film-maker, on the other hand, has the weapon, denied to his colleagues, of movement; further, he can commend *synthetic* movement through the powerful devices of animated diagram and other effects obtainable with the stop-motion camera and the optical printer (for example, the former can portray changing fields of force; the latter can present a filmed event backwards as well as forwards).

Thus the maker of scientific films has valuable tools for depicting the abstract and the invisible on the screen—provided he uses them imaginatively and skilfully. If he does, he may on occasion achieve levels of exposition far beyond the reach of the more static media.

In spite of this inherent power of the film to fire the imagination in scientific fields, there have been until recently few really good films on elementary physics. It is therefore interesting to look critically at five new films—one British, four American—on electrons and their applications. These are elementary technological films, suitable for use in physics or engineering courses and for general background education in science.

The British film, *They're called Electrons*, sponsored by the Edison Swan Electrical Company, though admirable in its intentions, falls down lamentably in execution. The purpose of this 40-minute film is to present to the layman or the beginner in science a broad picture of the electrical nature of matter, the behaviour of electrons, and a historical description of the thermionic valve. The film is spoilt by its laboured pretentious commentary, its weak humour, and some shoddy ideas—as for instance the occasional representation of the electron as a spherical face with a squint and sparks sticking out of its ears.

There are good parts, however, including a sequence of repeated subdivision, which conveys dramatically the idea of submicroscopic size; the description of electro-chemical action and operation of the battery; and the historical development of the diode. Though disappointing, this film could serve as a background introduction to the four American films.

These form a co-ordinated series on electronics sponsored by the U.S. Office of Education. Each film is part of a visual unit which also includes a film strip and an instructor's manual, and it should therefore be borne in mind that the films are not complete lessons in themselves, but concentrate only on the chief aspects of the subject. All the films are worth seeing if only for the sheer pleasure of following the smooth unfolding of the story. The chief character in the plot, the electron, passed through its various drills with a smoothness which is not only instructive but, in places, beautiful. *The Electron* (16 minutes) leads us through the existence and effect of the electron in fundamental electrical phenomena, and their application in practice. Alternating current, magnetism and induced current are all made clear with beautiful animation, and are followed by an excellent summary which leads logically to the subject of the second film, *The Diode* (18 minutes). Here the same clarity and smoothness are present. Special applications of the diode—the photoelectric cell and the X-ray tube—are instanced in a manner calculated to hold the interest and portray their fundamental properties. The explanation of rectification and the use of the duo-diode in practical circuits extends the usefulness of the film beyond purely theoretical instructional levels. It also leads naturally to *The Triode* (18 minutes), which introduces a delightfully graphic conception of the cathode-anode potential gradient—a diagrammatic "hill" caused by the space-charge, which the electron has to surmount before tumbling down to the anode. This third film lacks, however, some of the clarity of the first two in that the electron is temporarily relegated to second place in favour of symbolised circuit diagrams. This device tends to conceal the fundamental operation of the triode as an amplifier, but on the other hand perhaps aids the presentation of the more practical aspects.

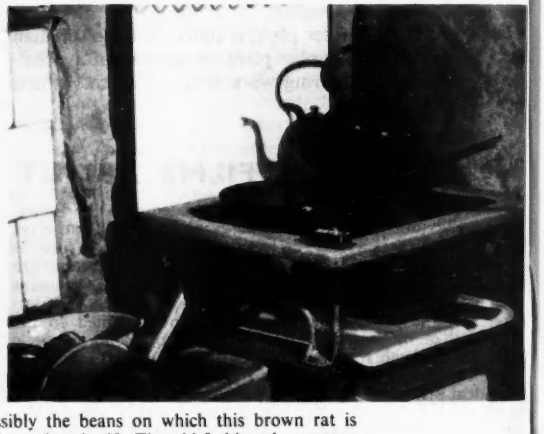
Principles of Gas-Filled Tubes (15 minutes) approaches once more the excellence of the first two members of the series. The influence of positive ionised particles on the space charge is well shown, and the practical application of the tube as a thyratron or a low-loss rectifier is clear in its fundamentals.

The visuals in these four American films—diagram throughout—are almost perfect in their spontaneous appeal to the imagination, the commentary is restrained and clear and the series forms a striking example of the teaching power of the film.

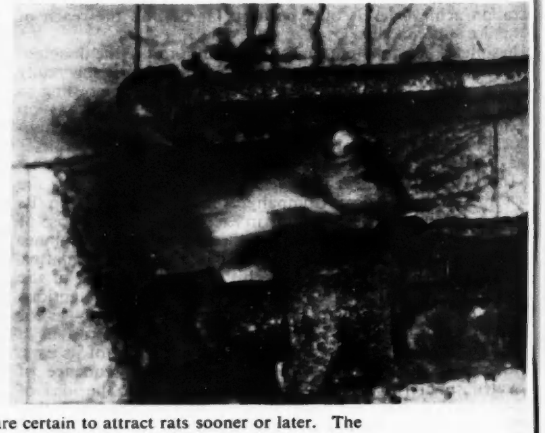
DENIS SEGALLER and PHILIP ARMITAGE.

This review is published by arrangement with the Scientific Film Association. Information on the availability of these films may be obtained from this organisation, whose address is 34 Soho Square, London, W.1.

1. Peering cautiously out from behind a pile of cartons is a rat. Its big upstanding rounded ears identify it as a black rat. 2. A cat—the traditional means of rat control—watches the hole. Even the best ratting cats are ineffective for large-scale extermination of these pests.



3. Spilled food in a store attracts rats. Possibly the beans on which this brown rat is feeding have spread from a hole gnawed by the rodent itself. The old-fashioned cage-trap is completely ignored. 4. Food left in a greasy frying-pan—or even the grease itself—brings rats into the kitchen. So do the greasy dishes in the sink.



5. Uncovered dust-bins full of rotting food are certain to attract rats sooner or later. The rat holes in the dilapidated walls show a regular infestation. 6. Heating and other pipes, passing through the house by unsealed holes in the wall, provide a convenient route. Notice the black smears made by the rats' bodies round the hole.

RATS AND RAT CONTROL

Pests of Stored Foodstuffs

P. B. COLLINS, B.Sc., A.R.C.S.

ONE-TENTH of the world's cereals and allied foodstuffs, according to a reliable estimate, is lost annually through rodent and insect pest infestations—a quantity, it is estimated, sufficient to supply a 1600 calorie diet for over 350 million persons, or to raise to a normal level that of three times as many adults who are at present underfed. These figures, admittedly approximate but certainly not an over-estimate, would be a matter of concern in even the most favourable times. But at present, when the storage and conservation of foods, and especially of the cereals, oilseeds and pulses to which the above figures refer, has become essential almost for the very survival of our civilisation, the problem is one that touches every inhabitant of our world.

Ever since Man first established stores of food, those stores will have been subject to the attacks of various creatures. But it has taken the foundation of FAO, and the collection and correlation, for the first time on a global scale, of facts and figures about food infestation, to attract the serious attention and active co-operation of many governments. This is in fact no domestic matter peculiar to any one nation; it is a problem of world-wide importance on whose solution depends the maintenance of the standard of living, admittedly already too low, of a vast proportion of the world's inhabitants. The knowledge moreover, that "most of this loss could be prevented by proper handling and storage" of the products concerned, gives additional impetus to the demand for more information about the 'how' and the 'why' of stored products pests.

The Rat Problem

While it is true to say that some pests are found in many homes, shops and small stores, it is those which attack the reservoirs of grain and other foodstuffs on which the balancing of the world's diet depends, which are now attracting universal attention. Not only are these a greater danger than at any other time in man's history; it is also a fact that an understanding on the part of a wide public, of the nature and magnitude of the problems they create, would go a long way to explain why plenty in one country may still not lead to the relief of distress in another, and why a full warehouse on the dockside may still not mean a full larder in the home. So much are we now dependent on foodstuffs grown in other countries, and stored there or in Britain, that a knowledge of these pests, so far from being the perquisite of a few select research workers in the fields of entomology and applied biology, is as much the concern of everyone of us as are those old family favourites, the clothes moth and the cockroach.

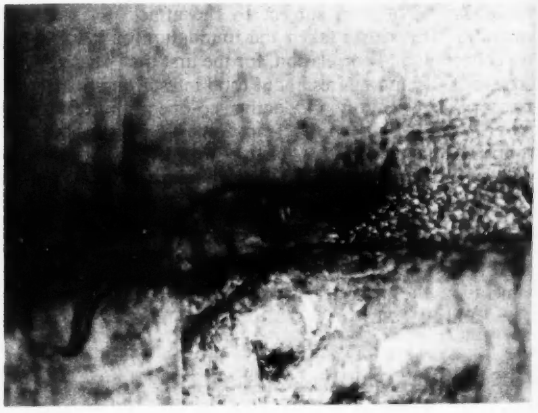
The phrase, 'stored products pests' is usually reserved for certain insects and allied forms, but is here used in a wider sense to include a group of creatures with which many of us are familiar—those ubiquitous and ruthless rodents, the rats and mice. And in the control of these, and of rats especially, probably a wider range of experts collaborate than over any other animal pest. For rat control as now practised, has long ceased to be the work of some picturesque old man dressed in rough tweeds—or even of 'the cat that killed the rat that ate the malt' of 'The House that Jack Built'. Both cats and old men, in fact, are being rapidly replaced by a team whose members range from the architect, who builds rat-proof stores and warehouses and the zoologist who studies the enemy's bionomics to find a weak spot in his defence, to the public health officer and the expertly trained operator, who put the others' theories into effect, and many other people in between. Statisticians, demonstrators and lecturers, doctors, film-makers and educationalists, are all called in at one stage or another in the fight against these rodents, which are probably the most universal plague the world can boast.

The Two Species

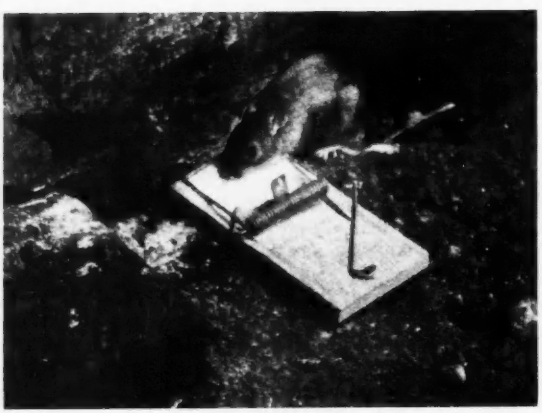
Considering the attention given to it, the rat is worth examining in closer detail—or rather, the rats, for there are two species which attract the notice of the authorities throughout the civilised world. These are *Rattus rattus*, the black rat, and *Rattus norvegicus*, the brown or Norway rat. The latter has the distinction of being, apart from *Homo sapiens*, probably the most successful mammal the world has ever known. Despite centuries of persecution wherever and whenever it has appeared, the Norway rat has spread from its probable home in Central Asia to every corner of the globe, and it has not only spread but firmly established itself and thrived. The reasons for this success are not far to seek. To voracious and omnivorous feeding habits, great stamina, adaptability and physical strength, the rat adds great fecundity. Becoming sexually mature at four months, a single pair of rats may produce up to twelve litters a year, averaging nine young to a litter; and even allowing for the normal average of six litters a year, and a survival rate of 50 % of the offspring, that pair living for three or four years will have produced a progeny running into astronomical figures. Small wonder is it then that rats have become first priority in pest control (in the U.S.A. alone they are reckoned to cost over $200,000,000 annually).

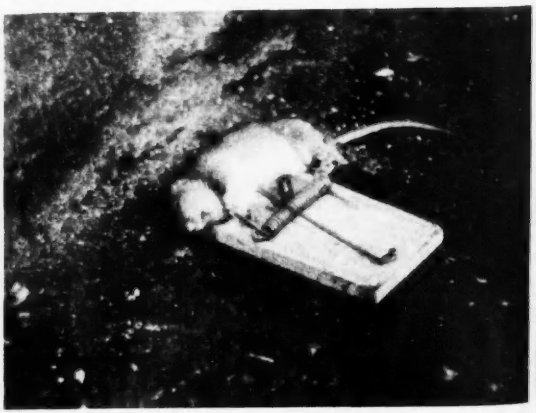
Nor does the black rat lag so very far behind. In some climates, especially in the tropics, this species, which is thought to have hailed originally from Arabia, breeds even quicker than *R. norvegicus*, and in Britain it has staged a notable come-back in recent years. At one time thought to be almost extinct, it has re-established itself in many areas, especially in seaports and big warehousing towns. This is due to its greater ability as a climber, enabling it by travelling overhead on wires and cables, to take possession of a building from the roof downwards, while a separate brown rat population lives in the basement. In appearance, these rats are quite distinct, *R. rattus* being characterised by a long, sharp muzzle, big upstanding ears, and a slender tail often longer than the rest of the body. The fur which is longer and stiffer than that of the brown rat, is dark-grey or blackish, paler on

7. Called in at last, the expert begins by pre-baiting with unpoisoned bait. The receptacle, too, is the same as that to be used later. 8. Now the poisoned bait is used. A brick on top of the lid prevents any domestic animals from getting at it.



9. Where the site is inaccessible to cats or dogs, baiting can be done in the open. Here a spoon is used to put the bait on a shelf. 10. Successful baiting leads to the death of another rat. Various poisons are used according to supplies and the site chosen.





11. As with poison baiting, so with trapping. The rat is "educated" by using an unset trap. 12. Success again. Though a rat will inspect most cautiously any fresh object, it cannot differentiate between the set and unset trap.

This series of photographs come from the film "Town Rats" made for the Ministry of Food by the Crown Film Unit.

the underside of the body. The brown rat, besides being a good deal larger, has a rounded muzzle, small ears, short thick tail, and is much the same grey-brown colour all over.

Great as is the material damage done by rats, not only directly but in the fouling of foodstuffs they do not actually eat, their importance as carriers of disease is even greater, and for that reason rat control has long been studied in all parts of the civilised world. It is however due largely to the necessity for ensuring even greater efficiency in food conservation during the recent war that biggest advances have been made, especially in this country. Rat control was during that period the special care of the Pest Infestation Department of the Ministry of Food (now transferred to the Ministry of Agriculture) and it is largely due to their researches that a really efficient technique has been worked out.

It is this technique that formed the basis for the following important resolution of the committee on rodent control at the Pest Infestation Conference, held under the auspices of FAO in London recently: "Poisoning after pre-baiting with plain baits is the only known method, of general application, that gives a profitable degree of success." A large accumulation of data has shown that this method is greatly superior to any other, and especially to the casual, *ad hoc* poison baiting, previously the usual routine, and now regarded as virtually useless for serious control. In the U.S.A., particular attention has been paid to preventive measures in the form of rat-proof building, which our more limited material resources have forced us to ignore to some extent. And even this is by no means the simple matter it might seem, for as the American authority, E. R. Kalmbach, has pointed out, two quite different means of approach are necessary for the two species. The brown rat attacking buildings from below as it were, can be kept out "by proper depth of construction and sufficient outward extension of foundations. With the several forms of *Rattus rattus* a propensity to climb up rough outside walls and within the partitions must be combated. This means barrier construction even above the ground floor, and all points of ingress and lines of travel, as along pipe lines and cables, must be blocked". And obviously, where both species are found together, the problem is even more complex.

Mice, although exceedingly troublesome in many places, do not attract such attention as their larger cousins and are often best controlled by trapping.

Owing to their smaller size, their 'radius of action' is less and baiting attracts only a local population living comparatively close to the bait. In some ways, in fact, mice have actually been found more difficult to control: it is fortunate therefore that they are at present of less importance.

(*To be concluded*)

Evangelista Torricelli (1608-1647)

A MULTITUDE of applications in pure and applied science found for evacuated tubes and vessels testify to the belief of early workers in the "power" of the vacuum, of men who disbelieved King Lear's reply to the fool who asked: "Can you make no use of nothing?" We can trace the growth of this cult from the classic experiment of Evangelista Torricelli, that disciple of Galileo who died 300 years ago. Torricelli did not invent the barometer, as is at times believed. His early death in 1647 cut off further inquiry into small daily fluctuations in the height of a mercury column, fluctuations he attributed to odd changes in the tube and mercury column itself. But it was Torricelli's inquiring mind—after Galileo had told how water could not be raised in a pump-shaft higher than 32 feet—which opened up all this worship of the vacuum, this study of the *horror vacui* leading centuries later to all that vacuum research has given us. Mercury in place of water, Torricelli surmised, would mean a tube only one-fourteenth as long for demonstrating a vacuous space above.

A commemorative notice of Torricelli must refer to other work, since centenaries are occasions to assess a man's position in the light of today's knowledge. Along with Viviani, Borelli the anatomist and others, Torricelli belonged to the Florentine Academy of Experiments. The pendulum swing of a lamp brought Galileo to the cause of science; Galileo's *Discorsi* in turn inspired Torricelli who himself wrote much on mechanics, extended Galileo's dynamics, and fixed the essentials governing velocity of efflux and parabolic paths of jets from orifices in the sides of vessels. Galileo made his famous telescope; Torricelli as disciple improved on it, and could base interesting work on the use of simple magnifying glasses from glass spheres. So did this classical era flourish with Torricelli and Viviani helping the blind Galileo to go on working.

But as so often happens in associating a man with one particular fact or deed, Torricelli goes down in the pages of history as creator of the vacuum. That single experiment began a new phase in science, a phase as stirring as anything in our history. Boyle, who had been nosing round Florence in 1641, conjured his air-pump; Konrad Sprengel gave us the mercury pump; Newton used a vacuum for his famous feather and guinea experiment. Acceleration set in as the fascination of the vacuum drew men like Cavendish, William Watson, Faraday, Crookes and his "dark space", Röntgen, Fleming and others who came under the spell. The epic tale of the vacuum began with modest Torricelli and now continues with the cyclotron and all that it means. And to prove that fact can outbid fiction at times one brings on that most striking figure among worshippers of the vacuum, Otto von Guericke, Mayor of Magdeburg, quartermaster in the Thirty Years War who found money for experimenting. After suction pumps and evacuated casks failed to satisfy him (or his showmanship), he it was who demonstrated the classic experiment of the Magdeburg hemispheres. How well the old print shows that vivid scene, with the two halves of the evacuated sphere pulled in vain by two struggling teams of horses, with the Prussian king and the Imperial Diet looking on bewildered at this strange power of the vacuum!

M. SCHOFIELD

Two major Television Advances

D. A. BELL, M.A., B.Sc., A.M.I.E.E.

Two major television advances have come into the news recently. The first enables television pictures to be projected on a flat screen. "The second makes it possible to relay programmes by radio links between television transmitters in different parts of the country. In a recent demonstration, for instance, vision signals from Alexandra Palace were picked up by a relay station 31 miles from London and then re-transmitted a further 24 miles, and plans have been completed for a chain of radio repeater stations to allow interchange of television programmes between the London service and the new transmitter which is to be built at Birmingham."

Projected Television Pictures

The first practical application of the optical projection of television pictures on to a large screen arose from the solution of the problem of cinema television, and this application is of some topical interest in view of the plan to equip five London cinemas with television this autumn. But projection television is also of interest to the home viewer, since despite the television experts who point out that a 5×4 in. television picture viewed from a distance of 2 ft. subtends at the eye about the same angle as a cinema screen viewed from a good seat in the theatre, everyone prefers a larger picture. (Perhaps one reason is that although a one-eyed man might get much the same impression in the two cases, a person with binocular vision knows that he is being 'cheated' by the small picture only two feet in front of his nose, because the angle of convergence of his two eyes tells him where it is.) So the urge has been for larger television screens, and by 1939 the cathode-ray tube—C.R.T. for short—in the larger receivers had grown to a diameter of 15 in., giving a picture about 12 in. wide. Another defect in C.R.T. television pictures is that the screen is curved. Since the war, flat-ended tubes have been developed in small sizes, but the large-diameter tubes must still have curved ends in order to withstand the atmospheric pressure, since the tubes are evacuated. So the production of a television picture which is flat and of size greater than 12 in. depends on finding some method of projecting an enlarged picture from the C.R.T. on to an external screen.

Optical Efficiency

A 16 mm. film projector may use a lamp of 400 watts, with a condensing lens in front and a reflector behind, and all the light which passes through the film will be directed by the projection lens to the screen. By contrast, even a 15 in. C.R.T. is likely to run at less than 100 watts, and the light generated on its screen is diffused in all directions. It is therefore no easy job to get sufficient light from a C.R.T. into a projection system to compare with the home cinema. A small C.R.T. is used to keep the optical components within reasonable dimensions, and this involves its own problems of screen brilliance and spot size; but it is still necessary for the aperture, or '*f* number', of the optical system to be very good. A lens with an aperture of *f*/3·5, which would be quite good for a camera, would collect only about 1% of the light radiated into a hemisphere; and to obtain an efficiency of 25% to 30% which is necessary with the limited light output of a C.R.T., the aperture must be better than *f*/1.

The device which has been brought into use in recent years is a version of the Schmidt optical system which was devised for cameras on astronomical telescopes. The idea is that the main optical component—preferably a mirror—is made with a simple spherical surface, and the various aberrations which result are corrected by a specially shaped correcting lens or 'Schmidt plate'. There are two main faults in the image formed by a concave spherical mirror: the image of a plane object is curved, and the definition is bad because for any fixed point of object and image the light collected by the outer part of the mirror is not focused at quite the same position as that collected by the centre. The curvature effect is conveniently overcome in the television case by using a curved object, i.e. the curved end of the C.R.T., from which a plane image is produced. The varying focal length of the different zones of the mirror is corrected by the Schmidt plate, which is placed in the plane passing through the centre of curvature of the mirror. There are many possible contours for the plate, but that shown (somewhat exaggerated) in Fig. 1 has one face plane and the other face convex near the centre and concave near the periphery. A hole is cut through its centre to accommodate the neck of the C.R.T.

In the diagram, *OO'* is part of the curved picture on the tube screen which is projected as a plane image *II'* by the spherical mirror. A pencil of rays similar to *OCI*, reflected from the central region of the mirror, passes through the correction plate at a point *Y* where it receives one particular degree of deflection; but a pencil of rays such as OPI from the periphery of the mirror receives a different deflection by passing through the plate at the point *Z*, and all rays converge to produce a sharply focused image.

A little thought will show that light from the centre of the C.R.T. screen which fell on the centre of the mirror would be reflected back on the tube, and by lighting up the shadows would spoil the contrast of the picture. This difficulty is usually overcome by leaving blank a disc in the centre of the mirror.

In most wide-angle optical systems there is a tendency for the centre of the field to be brighter than the edges. The blank disc at the centre of the mirror, which has just been mentioned, helps to overcome this, and the light distribution is further controlled by making the diameter of the correcting plate less than that of the mirror so that it acts as a 'stop'. These devices naturally cause some loss of light-gathering efficiency compared with that of a simple concave mirror.

Plastic Optical Components

From the point of view of quantity production, the non-spherical correction plate required by the Schmidt

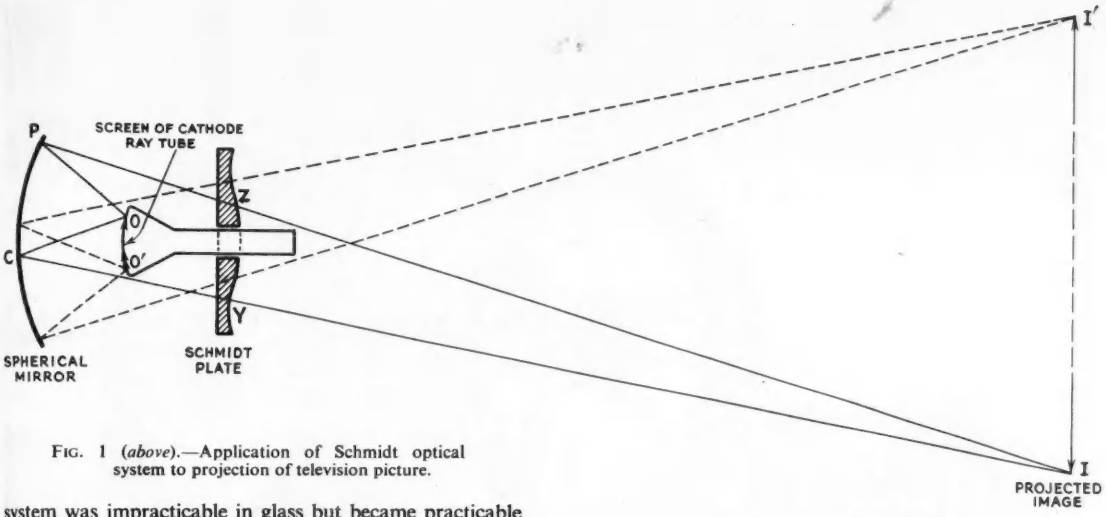


FIG. 1 (*above*).—Application of Schmidt optical system to projection of television picture.

system was impracticable in glass but became practicable as soon as plastic lenses were developed. One of the suitable plastics is polymerised methyl methacrylate, commonly known as 'Perspex' and in optical quality listed by I.C.I. as 'Transpex I'; and another is polystyrene, of which the optical quality is listed by I.C.I. as 'Transpex II'. Plastic lenses can be made by direct moulding, but there is some risk of thermal strains being trapped in the material on cooling, and later causing distortion if the lens is exposed to a substantial change of temperature. Therefore, I.C.I. who are planning mass-production in plastic material of both mirrors and Schmidt plates for projection television, have developed a new process known as 'surface finishing'.*

In a practical television receiver, the required distance between optical system and screen can be obtained within a normal cabinet by the arrangement of Fig. 2.

Translucent Screen with Controlled Diffusion

If the image is formed on the front of an opaque white screen (front projection) the light is scattered back in all directions according to Lambert's cosine law, and some of it is wasted in useless directions, so television is usually projected on to the back of a translucent screen. The danger then is that unless there is so much scattering material in the screen as to cause considerable loss of light, the brilliance will appear very great to an observer exactly on the axis of projection, but will deteriorate rapidly as one moves off centre. Some of the American television receivers have been fitted with screens of which the surface is embossed with an oval pattern of fine ridges to influence the spread of light, but probably the most advanced screen so far is one designed by I.C.I. which is embossed with a fine pattern of half cylinders ruled at 100 to the inch. These form cylindrical lenses which have their axes horizontal on one side of the screen and vertical on the other, and spread the illumination through an angle of 90° horizontally but only 30° vertically. A further advantage of this type of screen is that while light from the television picture is

* Details were given in a paper entitled "Plastic lenses in television projection" by Dr. D. Starkie, read to the Television Society on May 29, 1947.

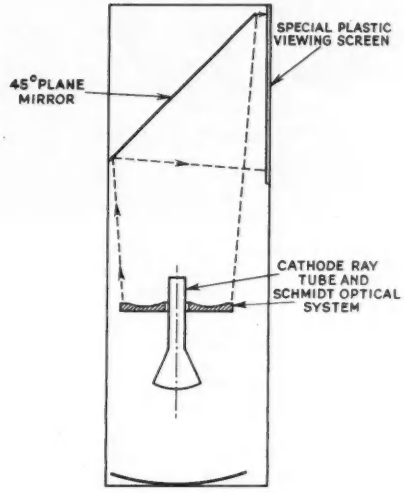


FIG. 2.—Method of mounting Schmidt system in television receiver.

concentrated within the desired angles, casual light from the room which falls on the screen is scattered at wide angles by the ribbed surface. Consequently the contrast of the picture is less affected by room lighting when one of these screens is used.

Relaying Television Signals

The special optical systems just described have made more practical the projection of television pictures on to a full-size cinema screen, a use of television which will shortly be demonstrated in some of London's cinemas. This may be of great importance, because although one tends to think of cinema and television as potential rivals, it was the representatives of the cinema industry who urged on the Television Committee the desirability of a higher standard of definition than the 405-line standard which is still used by the B.B.C. So far as cinema showings

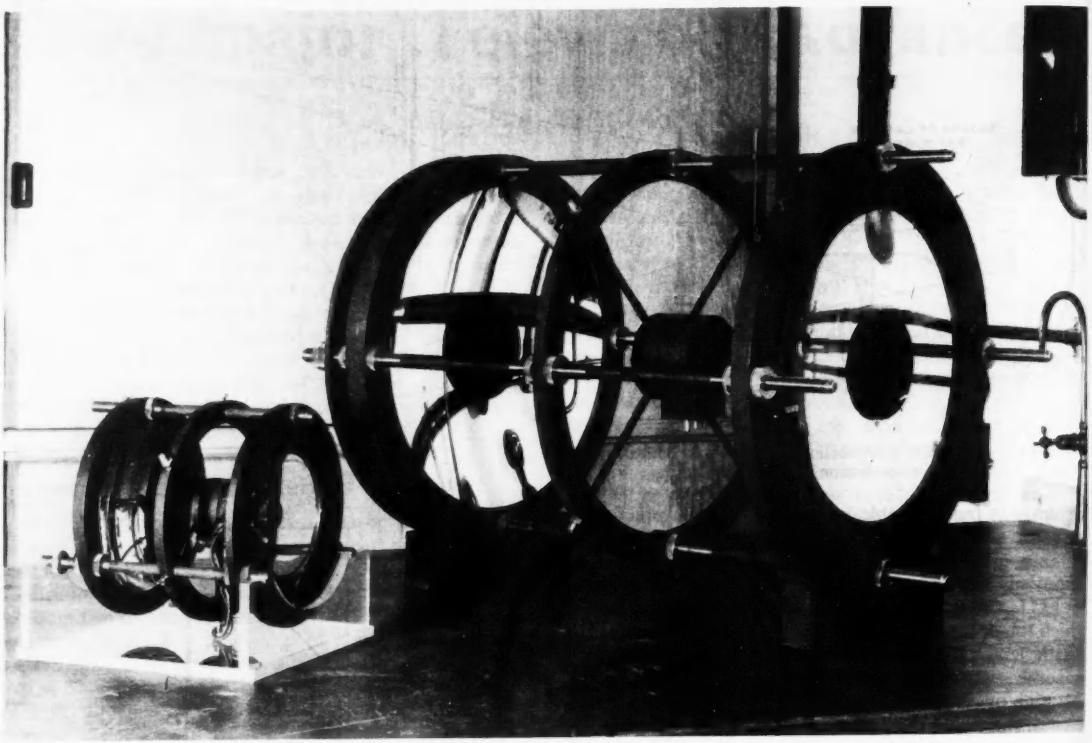


FIG. 3.—On the left is an 8-in. diameter Schmidt optical system for use in a domestic television receiver, and on the right an 18-in. diameter system which is designed to project a large picture on a cinema screen at a distance of 42 ft. The following details can be seen in the larger system: (*i*) At the left-hand end is the concave mirror, with a central disc blacked out as explained in the text; (*ii*) at the right-hand end is the Schmidt correction plate; (*iii*) the central ring supports an illuminated picture used for testing the system. In use, the screen end of a cathode-ray tube would be supported by this central ring, and the neck of the tube would pass through the blacked-out part of the Schmidt plate at the right-hand end.

of the B.B.C. programmes are concerned, the definition must be tied to the B.B.C. standard; but if it ever becomes economic to use television as a means of distributing film performances to a number of cinemas from a single celluloid copy, transmission systems of considerably higher definition will undoubtedly be built for the purpose, and the cinema is thus a force tending to advance television technique. Immediately, however, the impact of the cinema in television is to provide a wider market for television-relaying equipment, which would otherwise be used only by the B.B.C.

The importance to the B.B.C. of television relaying arises from the two factors of high cost of programme production and small service area of each television broadcasting station. The time and cost of production of cinema films is proverbial, but a television programme ought really to have more rehearsal than a film production, because once it is 'on the air' there is no possibility of cutting and re-taking an unsatisfactory scene. The production is then transmitted once only (to less than 20,000 television sets at the present time), as compared with a film, which can be distributed nationally and even internationally; and so the cost per viewer tends to be very uneconomic. Psychologically, the main attraction of television is that it presents 'the real thing', and the B.B.C. has wisely refrained from filmed repeats of its own productions which would bring it into direct comparison with the film companies' productions. The only method of reducing cost per viewer is then to present each programme simultaneously to a bigger audience than can be covered by a single transmitting station. The B.B.C. has not yet published a comprehensive scheme for television covering the whole of the United Kingdom, but it has been estimated that at least twelve transmitters would be needed to cover only the more populous districts of Britain with an adequate service, and there is therefore plenty of scope for relaying programmes.

Up to 1939 there had been three experiments in relaying television signals:

(1) In the West End, the actual vision signals could be sent to the Alexandra Palace transmitter partly over very short lengths of ordinary telephone line and for the rest over a specially-laid television cable.

(2) From favourable sites in and near London, the signals could be sent to Alexandra Palace by a radio transmitter, with a fire-escape ladder as portable aerial mast, on a wavelength about half that used for the ordinary transmission.

(3) A special cable was laid from London to Birmingham. Experiments showed that there were some

technical difficulties in the transmission of television signals over this type of cable, but it proved invaluable as a trunk telephone cable, capable of carrying simultaneously some hundreds of telephone conversations.

At this point television was shut down by the war, but radar requirements led to tremendous development of shorter wavelengths than had been used before—wavelengths of a few centimetres—and these are the chief medium for present-day television relays. The principal characteristics of centimetre waves are *first*, that their very high frequency should make them capable of being modulated by high signal frequencies, *i.e.* by signals conveying a great deal of detailed information in a short time; *second*, that the present-day generators of centimetre waves are not too easy to modulate; *third*, that the aerials can be very directional, concentrating most of the energy in a beam only about 5 wide; and *fourth*, that they can only be transmitted over a clear path such that apart from haze or cloud the receiver would be actually visible from the transmitter. In radar, such very short waves were only required to be sent out in pulses of constant amplitude, and their first application to other purposes was in modulated-pulse radio telephony in which pulses of constant amplitude were generated but either their widths or spacing varied in order to convey the signal.*

This method cannot be applied to television signals, since the frequency of repetition of the pulses which would be necessary in order to follow the detail of the picture would be much too high; and the first step in television relaying is the development of a continuous-wave oscillator. Compared with the peak powers of kilowatts and even megawatts which were used in radar, the television requirements sound modest: the Marconi equipment, for example, uses 5 watts for vision and one-tenth watt for sound, and has been demonstrated over a distance of 24 miles.† Frequency modulation is used for both sound and vision in this case, and it is believed that every practical television relay system now in existence uses either direct or indirect F.M. In the indirect method, the television signal frequency-modulates a radio-frequency oscillation which is intermediate in frequency between the television signal itself and the centimetre-wave carrier frequency. This oscillation is called a 'sub-carrier', and having been frequency-modulated with the television signal it is used to modulate the final carrier in either amplitude or frequency.

When radio relaying of television was first suggested, one of the anxieties was that distortions involved in the modulation and detection of the signal might add up to a serious amount when several relay links had to be operated in series. It is therefore interesting that one of the claims made for the G.E.C. system, which is being installed between London and Birmingham with two intermediate repeater stations‡ is that the actual vision signal does not have to be extracted from the radio signal at the repeater points. It is in fact possible to achieve this result with most F.M. systems. If a sub-carrier is used, the repeater station extracts the complete modulated sub-carrier from the received centimetre-wave and after amplification applies it to modulate the out-going signal of a slightly different wavelength. If direct frequency-modulation of the centimetre wave is used, it is possible at the repeater station to shift the frequency of the received signal and then amplify up to the power required for re-transmission without extracting the vision signal from the modulated carrier.

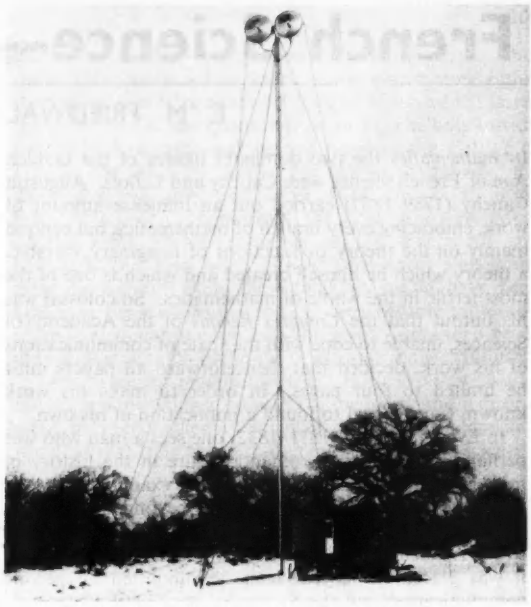


FIG. 4. A mobile relay station that has been tested for the relaying of television signals. Permanent relay stations operating on the same principle are to be built between London and Birmingham. (*Courtesy of General Electric Company*).

Although these centimetre-wave radio links are of considerable technical interest, the author hopes that they will be only a passing phase in the development of television relaying. Owing to the requirement for a clear optical path between transmitter and receiver, the equipment must always be mounted on a fairly conspicuous sky-line. We may then expect endless disputes of the type which has already occurred over the proposal to erect an experimental radio station on top of White Horse Hill, in which one has to attempt the hopeless task of balancing the value of amenities and sentiment against the cost of a technically less desirable route. The general trend in thickly populated areas of the world is for fixed point-to-point services to be carried by continuous conductors, at any rate over land, leaving radio for mobile and broadcast communications. It is not suggested that we shall return to the coaxial cable of the London Birmingham type, but rather that the next step will be to 'waveguides' in which radio waves of one or two centimetres wavelength are transmitted through hollow copper tubes. The minimum possible diameter of the tube is of the order of half a wavelength, so here again it is the development of shorter wavelengths for radar that has brought the waveguide scheme within the realm of practical possibilities.

The fact that in Britain all television transmitters will be operated by the same authority gives a special incentive to relaying techniques, and it is possibly that in this branch of television British engineers will keep ahead of other countries.

* "Radar Techniques applied to Radio Telephony", DISCOVERY, July 1946, p. 196.

† "Marconi Television Link", *Wireless World*, August 1947, p. 284.

‡ "Television Progress", *Wireless World*, July 1947, p. 247.

Continued from p. 273

French Science—Past and Present

E. M. FRIEDWALD, Licencié-ès-Sciences

In *mathematics* the two dominant figures of the Golden Age of French science were Cauchy and Galois. Augustin Cauchy (1789–1857) carried out an immense amount of work, embracing every branch of mathematics, but centred mainly on the theory of functions of imaginary variable, a theory which he himself created and which is one of the most fertile in the whole of mathematics. So colossal was his output that the *Comptes Rendus* of the Academy of Sciences, unable to cope with the spate of communications of his work, decided that thenceforward all papers must be limited to four pages. In order to make his work known, Cauchy had to found a publication of his own.

In Evariste Galois (1811–1832) one sees a man who was perhaps the most tragi-romantic figure in the history of modern science. He failed the entrance examination at the *Polytechnique* because his paper was beyond the grasp of his examiners. At eighteen he sent his first communication to the Academy, but it was lost by Cauchy in whose care it was placed. One year later he submitted his second communication, but the *Secrétaire perpétuel* Fourier, into whose hands it had come, died just then, and this paper also was lost. A third communication was pronounced incomprehensible by the mathematician Poisson. Meanwhile Galois had entered the *Ecole Normale*, but after a few months was expelled because of his political agitation which soon led to his imprisonment. Released after a few months, he picked a quarrel over a girl and fought a duel in which he met his death. The night before the duel, having a presentiment of his end, this boy of twenty feverishly summed up in a long letter to a friend the results of his work. And it was through that letter and through papers retrieved after his death that his work is known. This work which is contained in barely 60 pages has been proclaimed by mathematicians to be one of the most profound and original achievements in mathematics. Galois' masterpiece was the invention of the theory of groups which is of immense use in all branches of science. This boy of twenty, buried in a common grave, has been rated the equal of Gauss, Abel and Cauchy, none of whom surpassed him in originality and depth of thought.

Mention should also be made here of Jean Victor Poncelet (1788–1867) who invented projective geometry while a prisoner of war in Russia.

This was the time when *physics* was becoming more and more dependent on mathematics for its further development, and when the study of physical phenomena often led to new discoveries in mathematics. Outstanding amongst these mathematicians-physicists were: Jean Baptiste Fourier (1768–1830) who forged a new tool (known as the Fourier series) which proved of great use in physics, and created the analytical theory of heat; and Siméon Denis Poisson (1780–1840), who carried on the work of Laplace and applied to electricity and magnetism the mathematical theories of the Newtonian laws of gravitation. But by far the greatest physicists of this period were Fresnel, Ampère and Carnot.

Augustin Fresnel (1788–1827), after proving the correctness of Huyghens' wave theory of light as opposed to Newton's corpuscular theory, developed it mathematically and fully elaborated it. It is noteworthy that his crucial experiments were carried out with apparatus which had been constructed cheaply by himself with the aid of a village locksmith.

André Marie Ampère (1775–1836) had already made major contributions to mathematics and to the molecular theory of gases when, at the age of forty-five, he switched his talents to an entirely new set of problems. He set about investigating Oersted's discovery of the deflection of a magnetic needle by an electric current, and in a few weeks of feverish work established all the laws of force between a magnet and a steady current, proposing a theoretical explanation for them. These investigations were later described by Clerk Maxwell as amongst the most brilliant ever recorded in science. Incidentally, these researches were carried out in conditions of poverty bordering on destitution. Ampère used his own flat as his laboratory, and himself had to construct all the apparatus.

Sadi Carnot (1796–1832) was the son of the mathematician Lazare Carnot, the 'Organiser of Victory' of the Revolution. The whole of his published work, which was done independently of any school, is contained in a booklet of a hundred pages, *Réflexions sur la puissance motrice du feu;* of this it was said by Lord Kelvin that there was nothing greater in the whole field of science. Indeed this small booklet published in 1824 was actually the basis of thermodynamics. In it Carnot enunciated the second law of thermodynamics, and manuscript notes which only came to light long after his death make it clear that he had actually formulated the first law which was enunciated by Robert Mayer twenty years later.

Chemistry and Biology

In *chemistry*, this period saw the building up of the structure for which Lavoisier had laid the foundations. Many distinguished French workers added their contribution in this field. Louis Joseph Proust (1754–1826) formulated the 'Law of definite proportions'; Claude Louis Berthollet (1748–1822) first drew attention to the reversibility of chemical reactions; Joseph Louis Gay-Lussac (1778–1850) discovered that gases combine with one another in simple proportions by volume (Gay-Lussac's Law) and, together with Thénard, worked on chemical elements; Michel Eugène Chevreul (1786–1889) is known for his studies on fats; other names of note are those of Balard, Courtois, Vauquelin. On the whole it was the steady contributions of the many rather than the dazzling exploits of the few which characterised French chemistry in that period.

It was a very different case with the *biological sciences*. Here three great figures dominated the scene: Lamarck, Geoffroy and Cuvier, the founders of modern morphology.

Jean Baptiste de Monet de Lamarck (1744–1829) worked as a botanist at the *Jardin du Roi* until, at the time of the reorganisation of the *Jardin*—Lamarck was then fifty—he became professor of zoology at the same institution.

and it was as a zoologist that he carried out some of the most important biological work of the century. He was unquestionably the greatest systematist of his age, but he is best known for the theory of evolution which he propounded in his *Philosophie zoologique* in 1809, though some of the evolutionary mechanisms he outlined—for example the 'law of use and disuse', which assumed that acquired characters are inherited—were so startling that for a long time they received little serious attention, though eventually they did make a significant contribution to the progress of biological thought in that they stimulated others to think on evolutionary lines and to study the problem of the inheritance of acquired characters in particular. Lamarck gave to biology the unity which made it a true science and it was he who, simultaneously with the German Treviranus, introduced the term 'biology'.

Etienne Geoffroy Saint-Hilaire (1772–1844) and Georges Cuvier (1769–1832), at first together and later separately, formulated the basic principles of comparative anatomy. But whilst Geoffroy inclined towards evolutionism, Cuvier was a firm believer in the fixity of the species. The main conception that guided Cuvier was that of the 'correlation of parts' out of which arose paleontology. He was nicknamed the dictator of biology, and in fact wielded great authority and even determined the direction of biological activity in the first half of the nineteenth century. In France his influence was not altogether beneficial as he opposed any theoretical speculation not directly and fully supported by experimental evidence, in contrast to Geoffroy, who preferred to be guided to a large extent by hypotheses and ideas.

Three other notable figures which must be mentioned for their activity in the field of biology were: Xavier Bichat (1771–1802), the founder of histology and general anatomy; his pupil, René Théophile Laënnec (1781–1826), who introduced auscultation, the diagnostic technique which depends upon the use of the stethoscope; and François Magendie (1783–1855), who was the real initiator of the experimental method in physiology.

Science and the Universities

Most of these great names stand for new branches of human knowledge and bear testimony to the splendour of French science at the close of the eighteenth and in the early part of the nineteenth century. But even during this period which witnessed the greatest efflorescence of French science at its peak, there were already forces at work cutting at its very roots. The Wars of the Revolution and of the Empire had drained much of France's young blood, and that loss began to make itself felt in the 1830's. Moreover, with a declining birth-rate, France, which at the turn of the century had been the most populous country, gradually began to lose her lead. The truth of Bertillon's saying—that to maintain quality one must have quantity —became apparent.

Simultaneously the interest which French society had taken in science began to wane, and was succeeded by a growing indifference. Already Fresnel and Ampère had felt the pinch; Claude Bernard and Pasteur were to suffer even more. The universities might as well not have existed so far as their encouragement of scientific research was concerned. It is true that the Empire had created numerous faculties of sciences in the universities, but these were conceived as examination committees rather than as centres of research—a state of affairs which lasted until the close of the nineteenth century. The only institutions where research was carried on were the *Collège de France*, the *Muséum National d'Histoire Naturelle*, the *Ecole Polytechnique*, and, after 1830, thanks to more favourable political conditions, the *Ecole Normale*. Most of the great French scientists of the nineteenth and twentieth centuries were closely connected with these institutions. But while these facilities would have been ample in the eighteenth century, they became more and more inadequate to cope with the greatly expanded needs of scientific research in the age of growing industrialisation.

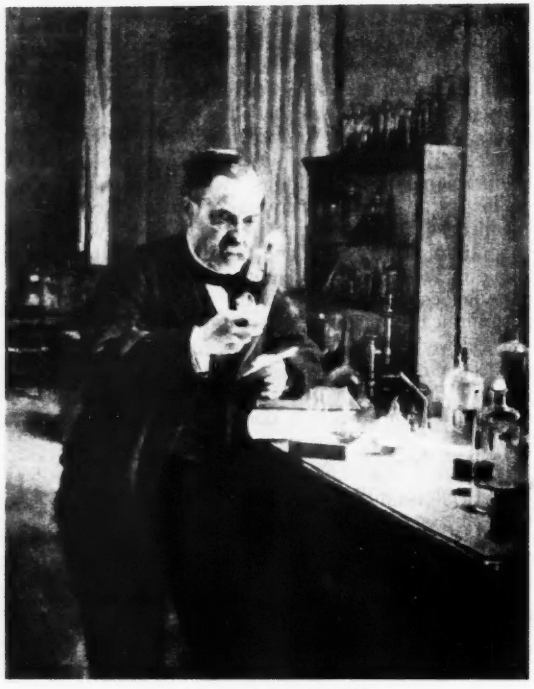
These were the material factors. But there was also an intellectual one connected with the mentality and temperament of French men of science: the positivist tendency which at that time began to dominate the French scientific outlook.

The Positivist Period

In 1830 appeared the first volume of Auguste Comte's *Cours de philosophie positive*, followed by five more volumes published over a period of twelve years. This work exerted a strong influence on French scientific thought and must be taken into account in any consideration pertaining to the development of French science.

Auguste Comte (1798–1857) was the product of the *Polytechnique*, a mathematician and philosopher who faithfully reflected certain latent tendencies of French scientific mentality, and thus came to create a veritable philosophy of science. He classified sciences in order of their genealogy and increasing complexity, starting from mathematics and passing through astronomy, physics, chemistry and biology to the social sciences. On this classification was superimposed the famous law of the three stages, i.e. the assertion that every branch of human knowledge passes through three successive stages, theological, metaphysical and positive. The last stage is that of science proper, limiting itself to what can be positively known, as opposed to metaphysical science which, seeking to know the essence of things, strives to build, on the basis of fragmentary facts, hypotheses from which spring a mass of theoretical speculation. According to Comte, the true scientist should limit himself to what can be positively established, scrupulously avoiding any theoretical speculation which cannot be confirmed beyond doubt by observation or experiment.

This attitude, which incidentally derived to a certain extent from Cartesianism, thoroughly permeated French scientific thought from that time onwards. And it was to prove a not unmixed blessing, for a too rigid positivism has often put a brake on French scientific thought and discouraged the building of working hypotheses which, though they cannot be fully substantiated, nevertheless can be of immense use in the advance of knowledge. In this respect there has been during the last century a marked contrast between French and German scientific thought, the latter often making use of working hypotheses, some of which, moreover, later proved positive realities. As long as the progress of science depended mainly on experimentation, the positivist tendency remained on the whole



Louis Pasteur 1822–1895.

an asset. But already in the second quarter of the nineteenth century theoretical speculation (for example in the realm of the atomic theory) was becoming a growing factor in the progress of science, and a too rigid positivism a handicap.

There were thus several factors contributing to the slackening of French science, even though the rest of the nineteenth century produced more eminent scientists than any previous period of the same length. But this growth has to be seen against the background of the special conditions created by the Industrial Revolution in France and elsewhere. The industrialisation, then in full swing, stimulated enormously the growth of science, and the fact is that France did not respond to the stimulus as effectively as, for example, Germany or Britain. The rest of the nineteenth century, though still a glorious period, was not nearly as prolific in genius as the previous two generations had been. No doubt many distinguished scientists left their mark on that period: the mathematicians Hermite, Lamé, Chasles, Darboux, Liouville, Bertrand; the astronomer Le Verrier; the physicists Regnault, Fizeau, Foucault, Cailletet, Pouillet; the chemists Dumas, Sainte-Claire Deville, Laurent, Gerhardt, Boussingault, Wurtz, Friedel, Le Chatelier; the biologists Milne-Edwards, Quatrefages, Jordan, Naudin, Brongniart, to quote at random a few of the better-known names. But there were only four figures comparable in stature to the giants of the previous two generations: Poincaré, Berthelot, Claude Bernard and, above all, Pasteur.

Henri Poincaré (1854–1912) has been called "the crowning of all the mathematical efforts of the nineteenth century", the man who wrote *finis* at the last page of many a fundamental problem in analysis and mechanics. His greatest work was done in the field of elliptic functions, but his achievements were great in every sphere of mathematics and astronomy, and his influence extended to experimental physics. It is interesting to note that it was his suggestion which led Becquerel to the discovery of radioactivity. He was renowned for his absent-mindedness, and achieved the rare distinction of being extremely popular, though most of his work could be understood by only a few men in the world.

Marcelin Berthelot (1827–1907) may be said to have been the dominant figure of the chemistry of the nineteenth century, if only by the sheer mass of his scientific output. He was the pioneer of organic synthesis and, with the Dane Thomsen, the main contributor to the development of thermo-chemistry. He enjoyed immense popularity and became successively Senator, Minister of Education and Minister of Foreign Affairs. But he was also a staunch positivist who for a long time refused to accept the atomic theory which had not then been substantiated beyond all doubt.

Bernard and Pasteur

Claude Bernard (1813–1878) has been called the "legislator of physiology". He was one of the greatest of biological thinkers and experimenters who first introduced the conception that the various forms of functional activity are inter-related and subordinate to the physiological needs of the body as a whole. His discoveries were legion but perhaps his greatest contribution was his *Introduction à l'étude de la médecine expérimentale* (1865), which is to the concrete sciences of the laboratory what Descartes' *Discours* was to the abstract sciences. It was mainly due to his work that physiology became as exact and precise a science as physics or chemistry.

Louis Pasteur (1822–1895) is perhaps the most popular figure not only of French but of world science. Indeed, he was the founder not only of bacteriology and microbiology, but of modern medicine itself. He was an outsider who came to biology by way of chemistry; and it was by his first great discovery, that of stereoisomerism, that he was led towards biology, establishing successively the nature of fermentations, the germ theory of disease and discovering the preventive treatment by inoculation. It is to the eminently beneficial character of his work as well as to his intrinsic greatness that his wide popularity is due. His work is one of the most comprehensive and fertile in the whole field of science. It brought into being yet one more of those famous institutions to which France owed so much of her scientific achievements: the *Institut Pasteur*, founded in 1886, which is both a centre for research and a seat of learning.

Unfortunately these few institutions had to compensate for the utter inadequacy of the universities. It was not until the end of the nineteenth century that it was recognised that Faculties of Sciences should be more than examination committees. However, the funds, when allocated to scientific research in universities, were so meagre as to make little difference in actual practice. Moreover, in the second half of the nineteenth century, the *Ecole Polytechnique* was taking on more and more the character of a breeding-ground for technicians rather than for scientists, whilst

the *Ecole Normale* tended increasingly to become the home of pure science. Together with the *Muséum*, the *Collège de France* and the *Institut Pasteur*, it remained the backbone of French science in the twentieth century. This state of affairs should be seen against the background of other countries, of Germany in particular, where dozens of universities, provided with the best available equipment, were springing up.

Lack of Support for Science

Nothing could give a better picture of the parsimony with which French science had to contend than the protests to which it stirred the two greatest experimentalists of the period, Pasteur and Claude Bernard. In 1867, Pasteur, on hearing that credits promised for the building of his new laboratory at the *Ecole Normale* would not be forthcoming, wrote:*

> Laboratories and discoveries are correlative terms. If you suppress laboratories, Physical Science will become stricken with barrenness and death. . . . Give it back its laboratories, and life, fecundity and power will reappear. Away from their laboratories, physicists and chemists are but disarmed soldiers on a battlefield. . . . Rich and large laboratories have been growing in Germany for the last thirty years, and many more are still being built; at Berlin and at Bonn two palaces, worth 4 million francs each, are being erected for chemical studies. St. Petersburg has spent 3½ million francs on a Physiological Institute; England, America, Austria, Bavaria have made most generous sacrifices. Italy has made a start.
>
> And France?
>
> France has not yet begun. . . . Who will believe me when I affirm that the budget of Public Instruction provides not a penny towards the progress of physical science in laboratories, that it is through a tolerated administrative fiction that some scientists, considered as professors, are permitted to draw from the public treasury towards the expenses of their own work some of the allowance made to them for teaching purposes.

In the same year, Claude Bernard, who worked at the *Collège de France* in a sepulchre-like cellar, wrote†:

> I have known the grief of the savant who, deprived of material means, cannot undertake or realise experiments which he has conceived, and is obliged to give up certain research work, or to publish his discovery merely in rough outline.

These two impassioned outcries give a good idea of the pitiful material state into which French science had fallen by the beginning of the twentieth century.

On the intellectual side, French scientific mentality and temperament were not in harmony with the exigencies of the Scientific Revolution. Science was passing the stage where it depended for its progress mainly on experimentation and positive realities. Physics as well as biology called for bold theoretical speculation and imaginative effort. And the ingrained positivism of French science was becoming a stumbling block to progress. Already in the nineteenth century it had impeded the development of the atomic theory in France, in spite of the determined efforts of Laurent and Gerhardt, who were the early pioneers in this field. And it is perhaps not surprising that neither in theoretical physics, nor in genetics did France

* *The Life of Pasteur* by R. Vallery-Radot, London, 1902, p. 199.
† *Rapport sur les progrès et la marche de la physiologie générale en France* by Claude Bernard, Paris, 1867, p. 148.

Pierre Curie.

make the contribution which might have been expected of her. Nor is it remarkable that the greatest of her contemporary scientists, Louis de Broglie, should be a 'metaphysicist' rather than a positivist.

Another detracting factor was the individualistic character of French science throughout its history. French science distinguished itself much more by great individual discoveries which opened up new fields than by the methodical co-ordinated effort needed to consolidate them. But the time was passing when science was to a large extent the product of the genius of a few individuals. Twentieth-century science was fast becoming a matter for planned and co-ordinated team-work to which French individualism could not easily adapt itself. The 'schools' which habitually form around great leaders of scientific thought were less frequent in France than in England, Germany or the U.S.A.

The Twentieth Century

In these circumstances it is not surprising that in the course of the twentieth century France should have fallen to the third or fourth place among scientific nations. It is not easy to single out either men or attainments for they cannot yet be viewed in an historical perspective. Most of the great French scientists of the twentieth century figure in the list of the Nobel prize-winners. There are to be found, in physics: Henri Becquerel (1852–1908), the discoverer of radioactivity; Pierre Curie (1859–1906) and Marie Curie (1867–1934), who discovered radium and polonium, and were among the pioneers in radioactivity; Gabriel Lippmann (1845–1921), who invented the capillary

electrometer and made important contributions to colour photography; Charles Edouard Guillaume, who invented invar and elinvar; Jean Perrin (1870–1942), one of the earliest atomic scientists; and perhaps the greatest of them, Louis de Broglie (1892–), who was one of the founders of the wave-mechanical theory.

In chemistry: Henri Moissan (1852–1907), pioneer of electrothermics; Madame Curie, who first isolated pure radium; Paul Sabatier (1854–1941), who is known for his work on catalysis by means of finely divided metals; Victor Grignard (1871–1935), the author of the Grignard reaction involving organo-metallic compounds, which has made possible countless new organic syntheses; and the Joliot-Curies, Frederic (1900–) and Irène (1897–), who discovered artificial radioactivity.

In biology: Alphonse Laveran (1845–1922), who discovered the malarial organism; Alexis Carrel (1873–1944), who was known for his work on tissue culture and who spent the last half of his life in the U.S.A.; Charles Richet (1850–1935), pioneer of serotherapy and anaphylaxis; and Charles Nicolle (1866–1936), who discovered the typhus organism.

Naturally this is not an exhaustive list of France's great scientists of the twentieth century, if only because such names as Langevin, d'Arsonval, Nicloux, Roux are missing from it. But nevertheless the distribution of Nobel prizes gives a fairly good idea of the relative position of nations in the scientific world. It also shows the sharp turn downwards which French science took as a result of the tremendous loss of young life sustained in the First World War. Between 1901 and 1913, France produced 10 Nobel prize-winners, as against 13 for Germany, 5 for Britain and 1 for the U.S.A. Since then she has only produced 7, as against 25 for Germany, 20 for Britain, and 21 for the U.S.A.

It must be borne in mind, however, that the decline had set in some hundred years before and that the wars had only accentuated a trend already in progress. One of the greatest handicaps French science has suffered in the last fifty years has been the indifference of industry towards it. This can be accounted for to a certain extent by the structure of French industry. Research on an adequate scale calls for heavy expenditure which can only be afforded by very large concerns. And France has very few large industrial concerns; her largest are no more than average size by German, British or American standards. A solution to this problem is now being sought by the setting up of a central research laboratory for each industry —paints and varnishes, textiles, rubber, fuels and lubricants, and so on—and under this scheme the costs of each central laboratory are shared by all the firms concerned. This scheme is somewhat analogous to the one which has given Britain its research association.

But an even greater handicap has been the indifference of the community and the Government towards scientific research. Strange though it may seem, until recently research workers in France were given neither status nor emoluments for their research work as such; only through the administrative fiction of their belonging to the teaching profession did they receive the salaries that enabled them to carry out research. It was only with the advent to power of the Popular Front, and thanks to the determination of Perrin, that things began to change. Shortly before the War there was created a central organisation for scientific research, the *Centre National de la Recherche Scientifique* (CNRS), and research, instead of being an annexe to teaching, became itself a profession in its own right. Research workers were given a status equivalent to that of the university teaching staff, carrying similar remuneration and the opportunity to interchange with teaching. At the same time there was an appreciable increase in the funds allocated to research.

Unfortunately the War put a stop to the whole project and today the problem of the finance of science is even more acute than it was in the mid-'thirties. Indeed, with impoverishment and constant inflationary pressure, the civil servants and particularly those engaged in science have been the hardest hit, while with so many urgent needs clamouring for attention, the demands of scientific research have been relegated to a back place. The greatest problem with which French science has to cope today is the shortage of research workers. The policy of the past hundred years did much to discourage the best type of French intellect from entering scientific research, and diverted it into the much more lucrative channels of industry. And as for industry, it has always regarded research as a sort of luxury to be dispensed with at the first sign of a slump.

It would be futile to speculate on the future of French science. All the potentialities of tradition, ability and intellect which could make France an ideal environment for scientific progress are there. No doubt the mentality and temperament of the French scientific intellect would have to adjust themselves to the changed needs of today's science; but this should not be beyond the bounds of French versatility. What will be far more decisive is the attitude of French society towards science. Once France has fully realised the long-term importance of scientific research and devoted to it the resources it calls for, there will be almost limitless possibilities for scientific expansion.

READING LIST

The number of books dealing with French science as a whole is limited. The most comprehensive account can be found in *Histoire de la nation française* by G. Hanotaux, Paris, 1924–25; Volumes XIV and XV are entirely devoted to the history of French Science. Two shorter accounts are: *La Science française, Ministère de l'Instruction Publique et des Beaux-Arts* Paris 1915 and 1933, and *La Science française depuis le XVIIe* siecle by Maurice Caullery, Paris, 1933.

The British Association at Dundee

The British Association at Dundee

SWORDS INTO PLOUGHSHARES. This was the theme that ran through the papers and discussions of the British Association meeting at Dundee from August 27 to September 3. This theme had been chosen by the Association's Council, who recognised the importance of emphasising at the present time the positive contribution of science to human progress. During six years of war British scientists had brought their techniques to bear on a myriad of military problems with outstanding success, and their eagerness to bring the full force of science into play for the purpose of solving peacetime problems was repeatedly in evidence during the proceedings at Dundee. There was practical expression of this attitude in the decision which was taken at the meeting to set up a special "crisis" committee, which will examine immediately how science can best serve the nation in the present emergency.

The President's Address

The presidential address by Sir Henry Dale was devoted to the subject of "Science in War and Peace". He dwelt at some length on the acceleration of scientific research and application to meet military needs that arose during the recent war, and in this connexion he referred to a number of specific examples.

The first he mentioned was radar, and here he posed the question, "How many decades of research, undertaken in response to no stimulus stronger than the desire to add to the resources of peace, would have been required for those developments of radiolocation and radar, which were achieved in a few years under the imminent threat and the realised peril of war?" It was certain that the scientific activities of peace had never witnessed anything like the intimate collaboration of British and American physicists and engineers, which finally played so important a part in giving full effect to this triumph of science in the service of war, with its value, so immediate, for the safety of transport in peace. Aeronautical science, having developed steadily in the inter-war years, sprang into a phase of headlong progress under the threat and the experience of the new war. And now we wait to see what will be the effects, on speed and safety in peaceful transport, of gas-turbine engines and jet propulsion, of stratosphere flight in pressure cabins, and of the fundamental changes in aircraft design, which are all still under rapid development.

There was no doubt, said Sir Henry, that the researches of Sir Howard Florey and his team on penicillin owed some of its stimulus to the gathering menace of war, and the lavish character of the industrial research and development which quickly overcame the difficulties of its large-scale manufacture chiefly arose from the recognition of its war-time importance. Sir Henry also cited work on anti-malarials.

Not all the uses of war-time discoveries in peace would depend on applications so direct and obvious. There were examples already, and it was most likely that more would appear, of inventions made with no purposes but those of war, which had found peaceful use in directions entirely unforeseen. Sir Henry selected as an example the artificial chemical substance, di-isopropylfluorophosphonate, now commonly known as DFP. This was first made and studied in this country, as an active member of a poisonous series, known to be under trial in Germany as potential weapons of chemical warfare. The actions of DFP, some of them unpleasant enough, were found by workers in this country, whose results were later confirmed by colleagues in the United States, to be due to its power of annulling the action of cholinesterase—an enzyme widely distributed in the animal body, and playing an important role in relation to the transmission of a number of nervous effects. DFP was never used, in fact, as a chemical weapon; but the action which might have led to such employment has already made it, not only a most interesting and valuable tool of physiological research, but also, according to recent news from the United States, an invaluable remedy, when suitably administered, for the dangerous paralysis of the intestine which may follow an operation. "So the wheel has come full circle, and the sword, forged as a lethal weapon, finds use, not only as a ploughshare of peaceful research, but even as a shield for threatened lives. This scientific by-product of war as now planned between the world's most advanced civilisations, thus seems likely to take its place with a number of poisons traditionally used by savage peoples for warfare, hunting, or murderous ordeal, which have already found applications in our modern medicine" said Sir Henry.

Besides the additions to physical and technical resources to research that the war had brought, science would benefit from lessons to be learned from war's experience of the methods of planning and organising, Sir Henry went on.

Wartime Lessons

He continued, "It may be of at least equal importance that we and the world should, with all rapidity and thoroughness, forget other lessons, which ought to be discarded. The conditions of scientific war service may have given to many a man a different kind of satisfaction, from any which had come to him from the normal experience of a scientist in peace. Some there must be, to whom this conscription of science for war gave even their first opportunity of testing the joys of research, and of putting their own natural equipment for it to the test of performance. And I suggest that there may be danger to science from a tendency to transfer too easily and completely, to the activities of peace, the attitude to research and the traditions of its conduct which have been acquired during six years of such war experience. I am not, of course, thinking just now of the perversion of science which war research involves through its particular business with the means of slaughter and destruction. For the moment I am concerned with the fact that the response to war's demands has led the majority of scientists of this country to devote nearly the whole of their thoughts and efforts, during six years or more, to practical problems presented to them for rapid solution. There must, indeed, be many younger men who have had little experience of other kinds of research than that which has been thus directed and even restricted to near and practical objectives and carried out under a pressure of urgency. From Government organisations and industry, awakened by war's experience to a fuller awareness of what science can do for them under such conditions, it is not likely that encouragement will be lacking for a continuation of similar activities into peace.

"Have not I myself been bringing to your notice lines of research which proved fruitful of practical result for the purposes of war, and should be continued and developed now, with a new orientation, to serve those proper to peace? I must make it clear, then, that it is far from my intention to suggest a predominance, in the programmes now to be shaped for science, of research enterprises such as those of war and of the methods by which they have been conducted.

Fundamental Knowledge

"Does anyone doubt that, to enable science now to render its best service to mankind, we need to take a long-range view and to give our first care to the extension of fundamental knowledge, unconstrained by aim at any practical objective? I am not concerned to advocate, or to defend, a philosophy postulating the advancement of pure knowledge on the one hand, or the material betterment of man's lot in the world on the other, as the ultimate motive of the scientific effort. I believe that it would be admitted, by partisans of either doctrine, that research which seeks only to advance pure knowledge commonly leads in the end to the widest practical developments; and that examples are plentiful of practical researches, conducted under conditions which leave full freedom to follow side issues, opening the way to great fundamental advances. The concentration, however, of practically the whole of a rapidly growing scientific effort on practical applications and developments, such as the war has witnessed, might find instructive analogy in a rapid extension by a commercial undertaking of its trading enterprise, without care to conserve and to expand its working capital; or in a reckless cropping of land, without care to nourish the soil. In theory I think that this is generally recognised, and I am far from suggesting that any of the different authorities which now provide material support for science in peace will hesitate to give generous encouragement to fundamental researches. My fear is rather that we scientists ourselves may find it difficult to shake off quickly the spendthrift habit in research, the policy of trading for quick returns, which six years of war experience may so easily have fostered, and may even have made congenial to many of us.

"I venture, further, to voice a hope that men with the rare, creative ability that science needs now for the resumption of its normal progress in peace, whose influence and example are needed in the schools for the inspiration of those who will follow, will not too readily assume, or too easily be persuaded, that their best service to science can still be rendered by planning and organising, or by bringing scientific ideas to bear upon policy. I believe that, under conditions now to be faced, the building up of our scientific capital of fundamental knowledge by those who have the creative gift should have a prior claim over its practical exploitation and over any cultivation of its political influence."

Sir Henry spoke of the new "obligations of secrecy" imposed upon scientists who devoted themselves so completely to the service of war in such fields as atomic energy. He urged scientists to meet the situation with a resolute watchfulness against any encroachment on activities proper to peace of a secrecy which was accepted as an abnormal condition in war, and with a determined effort to accelerate the liberation of science from all such entanglements. "I hope that we shall be able to ensure that the scientists of the near future will grow up as we their predecessors did, in an atmosphere of scientific freedom, so that they may be ready to accept, in their turn, the duty of standing, at need, in the defence of science in its full integrity. And I hope that we can keep as the constant aim of our endeavour, in spite of all present difficulties and causes of discouragement, the revival of an intimate brotherhood of the men of science of all nations, working together in full confidence, once more as a world community."

At the end of his speech Sir Henry Dale launched an appeal for the British Association's development fund, for which the target is £100,000.

Earth, Stars and Radio

In his presidential address, entitled "Earth, Stars and Radio", to the Mathematics and Physics Section, Sir Edward Appleton showed how the work of the radio-physicist linked up with geophysics, meteorology, solar physics and astronomy. G H and Oboe, the most accurate methods of position fixing, have been used for surveying purposes, and Sir Edward stated that, in particular, accurate maps of Anglesey had been made with both systems. Although these do not compare in accuracy with the best maps by triangulation they are very good, errors being of the order of 100 metres at most and usually only 20 or 30 metres. This is very much better than is available for large areas of the world.

"The need to correlate radio phenomena with meteorological conditions", continued Sir Edward, "has prompted the radio-physicist and the meteorologist to join forces in attacking the problems of what is practically a new subject, radio-meteorology. It is, however, already clear that the vagaries of ultra-short-wave transmission have led the meteorologist to recognise important phenomena in the lowest regions of the atmosphere which he had previously overlooked.

"If, for example, the temperature increases with height at the rate of 1 degree in about 9 or 10 metres, or the atmospheric water-vapour pressure falls by as much as 1 millibar in 30 metres, the diminution of refractive index with height is such as to cause a radio ray, starting out horizontally, to follow the curvature of the earth."

The Sun as Radio Transmitter

Sir Edward spoke of the radio detection of the Giacobini-Zinner meteor shower last October, and the attempt being made by the Manchester team led by Dr. A. C. B. Lovell to extend this technique with the aim of detecting ionisation bursts in the earth's atmosphere due to the entry of very energetic cosmic rays. He also mentioned the recent discovery of an entirely new solar phenomenon. "It has long been recognised that, since the sun emits visible and thermal radiation corresponding to a black-body temperature of 6,000 K., it must also correspondingly emit radio waves corresponding to the same temperature. But calculation shows that such radio wave intensity on a wave-length of, say, 5 metres, would be so small as to be undetectable with present-day techniques. J. S. Hey and I have, however, shown that during periods of solar activity, extremely strong radio emissions occur from sunspot areas, the maximum effect being observed on a wave-length of the order of 5 metres. Such abnormal radio emissions are more than a million times stronger than we should expect if the sun radiated as a black-body at 6,000 K. A sunspot is, in fact, the most powerful ultra-short wave radio station known, its power being much greater than a million kilowatts. Moreover, it has been found in experiments conducted in England in February of last year, that sudden large increases in intensity of solar radio noise have been observed to occur simultaneously with solar flares and radio 'fade-outs'." He said that ultra-short-wave radio noise originating from the Milky Way had also been received: a generally acceptable explanation of the phenomenon has yet to be given.

Colonial Research

Professor J. L. Simonsen presided over the meetings of the Chemistry Section, and his address was devoted to "Science and the Colonies". In the course of his remarks on the possibility of setting up chemurgic industries in the Colonies, he drew attention to the remarkable fact that sucrose (ordinary sugar) is produced in a pure state on a larger scale than any other organic chemical, but until recently it had received very little attention as a raw material for the chemical industry. One derivative, levulinic acid, could be converted into an excellent anti-freeze, and it also yielded compounds with promising chemotherapeutic properties.

Professor Simonsen emphasised that better nutrition of the people in the Colonies was of primary importance, and scientific efforts should be applied first to food supply and the prevention of disease. The new synthetic insecticides had brought a new era so far as diseases borne by the mosquito and tsetse fly were concerned.

"I would venture to suggest", he said, "that we already have sufficient knowledge to enable us to eradicate the mosquito from isolated areas. If applied on an adequate scale it should prove possible by their use to eliminate completely the mosquito from islands such as Cyprus, Trinidad and Mauritius, without in any way affecting the beneficent insects. The financial cost would be comparatively small and negligible compared with the gain in health and efficiency of the inhabitants. The control in Continental areas affords greater difficulty, but the results obtained by Symes and his co-workers in British Guiana and Uganda have already indicated that the problem is not insoluble." Professor Simonsen suggested that a solution to the tsetse fly problem may be found in insecticidal smokes applied either directly from aeroplanes or by smoke bombs dropped from them.

Geology and Coal Mining

Geological implications involved in the nationalisation of the coal mines were dealt with by the president of the Geology Section, Dr. M. Macgregor. The coal industry was already under a great debt to geology, but it was equally certain that the debt might well have been much greater than it is. "The fault for this, however, cannot be laid wholly at our door, but it will be our fault if we do not grasp the opportunities now offered in the new era that is opening out, opportunities not only for service to the country but also for the advancement of our science. Our contacts with the coal industry are now more direct and simpler. There need be no reservations or inhibitions, and there are no conflicting or competing interests to be considered. The information from borings, shaft-sinkings, adits, underground mines, cross-cuts etc., is now immediately available with a completeness that was not always possible before" said Dr. Macgregor.

He questioned the validity of available statistics for national and world coal reserves, and suggested that the whole problem of world coal resources needs re-examination on a new basis, taking into account other factors besides geological distribution. The more geologists knew about the history of the Carboniferous rocks and the conditions under which these were formed, the more complete and useful would be their contribution to economic development, particularly of the deeper and less accessible reserves.

Examples of the work done by zoologists in the war were given by Dr. Edward Hindle, president of the Zoology Section. He spoke of Dr. H. B. Cott's contribution to army camouflage and the researches directed by Prof. J. Harris at Millport which led to improved measures for dealing with the fouling of naval vessels by marine organisms, and also called attention to the activities of the Infestation Division of the Ministry of Food, the

bulk of whose inspectorate consisted of war-time graduates.

Zoologists on Operational Research

Dr. Hindle disclosed some facts about the zoologists brought into operational research. "Their training was found to be an excellent foundation for the study of various military problems ranging from statistical investigations on the most efficient methods of bombing and the interpretation of the results, to the development of radar, meteorology and even the possibilities of psychological warfare", said Dr. Hindle. "At least sixty zoologists were commissioned to various arms of the Services. Much of this work is still of a very confidential nature, but I am at liberty to refer to one example, the practical development of radar, especially in connection with gun-laying devices for anti-aircraft guns, which was very largely the work of a team including a number of zoologists, among others L. Harrison Matthews, David Lack, G. C. Varley, H. G. Callan and H. D. Slack, who went out to the A.-A. gun-sites and helped to maintain radar during the early attacks in 1940. Later R.E.M.E. was formed and carried out these duties, but most of the zoologists were invited to join operational research groups in different arms of the Service.

"When the Air Council in 1942 decided on the development of a promising device called 'H2S' one of these teams investigated the apparatus, and when it was being produced in quantity in December 1942, at once tested the sets and helped to make them operate. They also personally installed them in the first two squadrons of aircraft. The original gear refused to work, but, by the middle of January 1943, various modifications had been developed and several aircraft had been equipped and were ready for trial by the R.A.F. One of the great difficulties of radar is that, unlike wireless, when a set is switched on it does not always work automatically, but seems to be extremely temperamental and often gives unexpected results. Zoologists proved to be particularly well fitted to cope with these difficulties, since by their training they become accustomed to handling large numbers of uncontrollable variables. The part they played in 'providing the tools' has received very little public recognition, yet the practical application of radar was one of the deciding factors in the War. There was certainly some justification for the selection of an academic zoologist as the central figure of that somewhat melodramatic film 'The School for Secrets'."

Turning to peace-time problems, Dr. Hindle focused attention on the huge losses of foodstuffs caused by insect pests, and said that the U.S.A. was spending £2 million a year on entomology as against £500,000 expended by the British Empire—relative to income, the Americans were devoting seven times as much money to the subject as the British Empire. Finally Dr. Hindle spoke of the educational value of zoological training far exceeding its economic possibilities; the number of openings for professional zoologists was not likely to exceed about fifty a year, but as a general educational subject in schools zoology might well take a more prominent place.

Geographers' War Service

The subject of the address by Professor Eva G. R. Taylor, president of the Geography Section, was "Geography in War and Peace". In both World Wars there had been a sudden rise of geographical prestige, said Professor Taylor, and geographers had been seconded to Government Departments such as the Ministries of Supply and Economic Warfare, while others had organised geographical intelligence to the various Commands, in many cases applying such intelligence to the novel and intricate needs of commandos and bomber-pilots, for instance.

Referring to geodetic research, Professor Taylor said, "We ourselves are perhaps startled to hear it suggested that the exact size and shape of the earth may be elevated to the rank of 'top secrets': startled until we remember that success in mechanical warfare depends upon pin-pointing the target—a target out of sight round the bulge of the earth. Yet since we possess maps of the world the problem might seem to be one of computation only until we recall that a mere fraction of the land surface has been covered by instrumental survey of the order of precision really necessary, and that the tying together of such exact surveys as are complete has often not been done directly on the ground (indeed the oceans intervene) but by calculation based on an assumed figure of the earth. If the map of Burma were much less than the ten miles, or ten minutes of the arc, out of the true that has been hinted, then while radar-directed planes or atom-bomb-loaded rockets might reach the latitude and longitude at which they were aimed, they would not reach their targets."

For the fighting man, apart from exact position, there is no detail of terrain so minute as to be completely unimportant, and the future lies in photogrammetry, in stereoscopic surveying and mapping from the air from which there is no defence. In peace it could provide far more precise crop-forecasting than farmers' estimates. After sketching how geographical knowledge had brought to bear upon problems of planning beach landings on D-Day, Professor Taylor concluded her address by stressing the point that if the recognition of the regional differentiation occurring within the framework of the earth as a functioning organic whole is to become, as it should, part of the mental background of every thinking person, then much more attention should be paid to maps and globes.

Professor D. H. Robertson, as president of the Economics and Statistics Section, reflected on the economic outlook. There was a widespread and growing conviction that the conversion of "Swords into ploughshares" required a national plan, but it did not seem at all clear that there was no real difference of kind, but only of degree and pace between the conceptions of Liberal Interventionism and Planned Economy. It was foolish to speak as though the difference were the difference between anarchy and order.

"Physiology and the Community" was the title chosen by Professor Winifred Cullis for her sectional presidential address, in which she commented on the improvement in recent years of biological and physiological teaching at training colleges. She also praised the B.B.C. school broadcasts on physiology and hygiene.

A Survey of Engineering Progress

Sir William Halcrow devoted most of his presidential address to the Engineering Section to a historical survey of progress in various fields of engineering, civil, mechanical and electrical. He enumerated the conditions of survival of railways in the modern world; improvements must come in three directions—better technique and equipment for the clearance of breakdowns are long overdue and it is possible that frequent lay byes and passing places will be required; the block signalling system appears to be somewhat 'remote' for modern load intensities; the dead load of rolling stock approaches a ton for every passenger carried, much too high for flexibility. Sir William saw the gas turbine as superseding the internal combustion piston engine. "It may be that with its advantages in fuel ancillaries it will challenge the steam turbine eventually. At present its life is too short for purely industrial processes and a technique of rapid replacement may have to be developed."

Giving his support to the Severn Barrage proposals, Sir William said that this hydroelectric scheme was capable of generating 2300 million units at a cost of one-fifth of a penny at the switchboard. Silting problems in connection with the Severn Barrage had been investigated with models which made it possible to reproduce 78 years of the history of the estuary, and by inference the future could be foretold. Sir William spoke of the new laboratory being set up in this country by the Hydraulics Research Board of the Department of Scientific and Industrial Research, under the direction of Sir Claude Inglis. One of its first works would be a new model of the Severn Barrage.

"The Anthropological Approach in Social Science" was the title of Professor Daryll Forde's address to the Anthropology Section. He said "the anthropological outlook with regard to social science is characterised by two complementary approaches. On the one hand, it seeks to determine the structure of social relations among any given people in terms of a comprehensive observation of their cultural norms. While it may be necessary to concentrate on some aspect of the culture or of social relations, particular institutions are not divorced from the total cultural context, nor is the social structure described and analysed only in terms of the ideal patterns or vitiated by acceptance of the rationalisations of the people themselves. In short, the anthropological aim is to determine and interpret social systems in terms of comprehensive

ethnographic data. On the other hand, the anthropologist views any given society as one exemplification of general processes whereby aggregates of the human species cohere in response to the physical condition of their habitat and to their psychophysiological drives as organisms. His analysis of any one community is informed by the need to present data that are significant and accurate for subsequent comparative studies. And in these comparative studies he seeks through the detection of concomitant variations both within the social structure and between it and the external environment or the organic conditions of the population, to isolate abstract but recurrent properties inherent in a range of concrete behaviour whose functional dependence on other properties of the social system or on biophysical determinants may then be determined."

Personnel Selection

Personnel selection in the British Army and vocational guidance of children provided the 'war' and 'peace' aspects of Dr. S. J. F. Philpott's address to the Psychology Section. The Army required a system within which those working under the Directorate of Selection of Personnel could handle (*a*) millions of men generally, and (*b*) smaller numbers of potential workers at certain highly skilled jobs. For the former the first requirement was a test of all-round ability. There were many such tests. The Army used several, the best known being the Matrix Test given to all recruits on joining. From this, the man's general level was determined. Depending on his results in that test, and on his civilian record, other tests were applied, tests of simple arithmetic, of simple science, of mechanical ability. For potential signallers there were tests of hearing and Morse aptitude.

Working out a lower limit, and sometimes an upper limit, for this task or that in the Army, whether for intelligence, mechanical ability, hearing, ability to do arithmetic, and so on, it was made possible to supply Personnel Selection Officers with a broad scheme within which to work. Given a man's scores for the various tests they could tell at once whether he was too good for this task or not good enough for that. The popular interpretation of tests tended to ignore man's versatility somewhat, while at the same time over emphasising the extent or measure of variability as between the various parts he may be playing. In practice the essential measure was of all-round ability; in addition to this there must be a scheme of cut-off requirements —some occupations require that a man should have two legs, but for others an artificial leg would not necessarily disqualify.

"We get the same kind of thing in the educational world. Entry to a grammar school obviously depends on all-round ability. Unless the child is intelligent enough, he will not make the grade. But there are a few cut-off requirements as well. No matter how intelligent he is, he will not be a suitable candidate unless he can read and write. He must have those two techniques if he is to gain anything at all from the grammar school curriculum. He must also be able to do simple arithmetic. But beyond a few very necessary requirements of the kind, the fewer tests the better—once those of all-round ability are given and passed."

Anti-Artificials School Attacked

A strong attack on the 'anti-artificial-fertiliser' school was made by Dr. W. G. Ogg in his presidential address entitled "Soils and Health" to the Agriculture Section. The opponents of artificial fertilisers, he said, are quite unscientific in their outlook, but often use or misuse scientific terms, and some of them carry out what they allege to be scientific experiments.

An attempt had been made to create a controversy where in fact there was none, for every scientific agriculturist realises the value of organic manures and advocates their careful conservation and fullest possible use. It is not a case of choosing between them and fertilisers. Both have their uses and 'artificials' should be regarded as complementary to good farm-yard manure.

There has been much talk of composts, and these are excellent as far as they go, but on a clean well-managed farm, run on ordinary lines, the amount which could be prepared from the weeds and crop residues would be quite trivial. True, it would be possible to organise the production of crops for composting, but the land and labour required for this would very greatly increase the cost of our food supply and reduce the area of land available for food crops. Under most systems of agriculture today the amount of farm-yard manure produced was quite inadequate. Moreover when a soil deficiency occurs, the crops and, in turn, the farm-yard manure or composts tend to show the same deficiencies. The claim that 'artificials' adversely affected the soil's population of microscopic living things was not supported by facts.

It was also contended that fertilisers reduce the earthworm population of the soil, but this was not borne out by recent work at Rothamsted. Plots which received heavy dressings of sulphate of ammonia were compared with unmanured plots and the former contained as many earthworms as the latter, but the weight of worms on the nitrogenous plots was much greater, due presumably to the greater amount of vegetation (roots, stubble, etc.) produced as a result of the extra nitrogen. The incidence of some plant diseases increased with nitrogenous manuring, in others it declined—but it did not appear to make the slightest difference whether the fertilisers were organic or inorganic.

"The provision of greatly increased supplies of synthetic nitrogen and other fertilisers is one of the most obvious means of combating the present widespread famine," said Dr. Ogg. "Fifty thousand tons of additional nitrogen properly distributed would give an extra million tons of wheat or rice. For the season 1946–7 the Combined Food Board was faced with reasoned demands for 3·3 million tons of nitrogen which was twice the previous year's consumption and fifty per cent above pre-war production. Probably more can be done for the improvement of health in the world today by providing ample supplies of food than in any other way, and the propagation of unfounded beliefs about the harmful effects of fertilisers is detrimental to the interests of the whole community."

Dr. H. Hamshaw Thomas's address to the Botany Section resolved itself into a plea for further research on fossils which shed light on the origin of flowering plants, and a reconsideration of available data. Evolution now held a place in biology as fundamental as the concept of atoms and molecules in chemistry. Students were taught about evolution at school in the earlier stages of their biological training, and it had come to be held as an article of faith. Several branches of modern botany were largely based on the belief in evolution as a fact, and every branch had been influenced by the concept to a greater or smaller extent. Much progress seemed to have been made towards an understanding of the possible mechanism of evolution, but little or no progress had been achieved in proving by the production of actual historical evidence that evolutionary changes have taken place in the form and structure of plants. "Can we truthfully say that we know very much more about the history of the flowering plants and the fungi, the two largest groups of living plants, than was known in Darwin's day?" asked Dr. Thomas.

The presidential address to Section L was given by Miss Lynda Grier, her subject being "The Evolution of Secondary Education in England".

The First British Atomic Pile

Over 200 papers were read at the meeting and here it is only possible to refer to a few of them. Of exceptional interest, since it gave some details of the atomic pile that had just come into operation at Harwell, was that of Professor J. D. Cockcroft. This atomic pile, which started working on August 15, uses graphite as the neutron moderator, took a year to build and has a maximum power output of 50 kilowatts. Professor Cockcroft gave figures which showed how the pile 'warmed up' during the first few days. By using boron trifluoride gas in an ionisation chamber a count of the neutrons was enabled to be made. On August 7 when 7 tons of uranium had been loaded into the pile, there was an output of 17 neutrons per square centimetre per second. On August 11 when 12 tons of uranium had been loaded the rate of neutron emission had arisen to 55 a second. On August 13 with the same amount of uranium there were 214 neutrons a second, on August 15 at 11 a.m. 2400, at 1 p.m. 6600 and at 3 p.m. there was saturation. Above this point the power level of the pile increased slowly. Saturation came about when the power level was one-tenth of a watt. When the power level reached 100 watts the safety rods were inserted.

Professor Cockcroft said that no elaborate methods for cooling had been devised,

but the pile will not be able to operate much above 50 kilowatts because the uranium rods will get too hot. This experimental pile is a source of neutron energy about ten times stronger than the largest cyclotron.

The use of radio-active isotopes which the Harwell and other piles will be producing was discussed at a joint meeting of the Chemistry and Physiology Sections. Dr. A. S. McFarlane speaking on the "Biochemical applications of Stable and Radio-active Isotopes" said that radio-phosphorus, because of its convenient half-life and suitable radiation characteristics, and because of the widespread distribution of phosphorus in the animal body, has found wider application in biochemical studies than any other radio element. It was adding new evidence to increase our knowledge of the biochemistry of the living cell. The use of radio-active iron has brought to light the remarkable control which the body exercises over the absorption of iron from the gastro-intestinal tract.

Radio-active carbon, which is now being produced in milligram quantities, is finding a wide field of application in animal experiments.

Search for New Coalfields

As was to be expected, in view of the overwhelming public interest shown in the subject, coal was much discussed. The presidential address to the Geology Section was concerned with geology in the development of the coalfields. In the subsequent discussion on the future of coal supplies, Dr. G. M. Lees spoke on the prospects of discovering new coalfields in the United Kingdom. He said that there is extensive exploration going on at present in the Midlands and South-Central parts of England. As a result of these investigations new discoveries of coalfields are thought possible. The areas being investigated are:

(1) In the vicinity and to the west and south-west of Market Drayton in Shropshire, and near Burton-on-Trent.

(2) In Wiltshire as an eastern continuation of the Somerset coalfield, or perhaps as an independent coalfield.

(3) In the Cotswold country of Gloucestershire, and perhaps in Southern Worcestershire.

(4) In certain areas in Oxfordshire, perhaps between Oxford and Reading.

(5) In Eastern Essex.

In addition to these, said Dr. Lees, extensions of known coalfields are possible.

Dr. Lees mentioned that so far an extensive coalfield has been discovered by borings in Central Lincolnshire, but although the seams are too deep for present-day exploitation (4000 to 5000 ft.) there is a good prospect that the Measures will rise to lesser depths in the vicinity of the Wash. The possibility of Coal Measures in North Norfolk has been disproved by a boring at North Creake.

On the question of coal as a source of heat and power, Professor D. M. Newitt speaking on "New Developments in the Technology of Coal Carbonisation and of Gas Distribution" said that about one-quarter of the total yearly output of coal is today consumed in old-fashioned and inefficient open grates. From every point of view, he emphasised, this practice is undesirable and more efficient methods, based upon electricity and gas, should be substituted. For dealing with a rapidly expanding demand for gas, efficient processes were needed for the complete gasification of coal, the production of gas of a much higher calorific value than coal gas, and the storage in liquid form of the higher calorific value gas might be required.

Sir Henry Tizard who succeeds Sir Henry Dale as President of the British Association.

The coal-miner himself was not omitted from the discussions. A joint meeting of the Psychology and Physiology Sections on "Man and the Machine" brought a paper from Professor R. C. Browne in which he considered the many problems which arose out of the conditions caused by man's use of tools and machines in the industrial world. He thought it might be possible to devise means to produce a more complete and harmonious partnership between man and the machine. He said the coal mining industry provided an example of a situation in which the failure to adapt to the physical, physiological and psychological conditions produced such complicated effects upon the miner that his health and work both suffered. One particular aspect of the miner's working conditions—the darkness—made a massive contribution to the number of accidents each year, and also helped to produce a specific miner's eye disease—nystagmus—which usually carried with it a psychological breakdown. The dusty atmosphere of the work, too, caused lung diseases from which tens of thousands of miners were suffering.

Another subject of great topical interest, food, was also on the agenda, and a discussion on "Could and should Britain feed herself?" was opened by Mr. Walter Elliott, M.P.

The expansion of food growing in Britain was now a "must" he said, and the chief factor still apparently lacking was a sense of urgency. Britain had reached a pass at which effort must be expanded even to the point of diminishing returns, and many risks taken. He thought it was possible to feed a third of the population, but that would require effort and organising ability on a scale greater than had been evinced yet.

On the other hand Mr. H. D. Walston thought that Britain could feed herself, but that it would involve radical adjustments in our economical standard of living. The limiting factors in agricultural production, he said, was not land, but labour, machinery, fertilisers and feeding stuffs.

In a discussion on the biology of the soil new facts about earthworms were given by Dr. A. C. Evans of Rothamsted Experimental Station. He said that the weight of wormcasts thrown up on to the surface of a field does not depend on the total earthworm population but only on the numbers and average size of two particular species of earthworm. The annual production of wormcasts on a series of fields at Rothamsted is estimated, he said, to vary from 1 to 25 tons per acre, but the total weight of soil passing through the digestive tracts of the earthworm population is greater—4 to 36 tons per acre.

In the Physics Section Dr. R. L. Smith-Rose speaking on "Location of Thunderstorms by Radio" said "the best known method of determining the positions of lightning flashes or other discharges, which cause atmospherics, is to use radio direction-finding equipment with visual presentation of the direction of arrival on the screen of a cathode-ray tube. By making simultaneous observations with three and preferably four such equipments at widely separated points, the sources of atmospherics are determined by the intersection of the observed directions of arrival.

In the same section, Dr. A. B. Lovell announced that he had recently observed noises in radio receivers due to the aurorae or 'Northern Lights'.

Over three thousand members of the British Association attended the meeting, the local membership having reached the record figure of 1700. Sir Henry Tizard, who is chairman of the Government's Advisory Council on Scientific Policy and of the Defence Research Policy Committee, was elected president for 1948. Next year's meeting will be held at Brighton. In 1949 the British Association will visit Newcastle, and in 1950 the annual meeting will be at Birmingham.

The Bookshelf

Molecules Against Microbes. By E. S. Duthie. (Sigma Books, London, 1947; p. 156, 6*s.*)

THE writer of popular scientific expositions is faced with the problem of evoking the interest of the layman without provoking the scorn of the expert. Both kinds of reader can seldom be satisfied simultaneously and nearly every piece of work in this class is a compromise. In this remarkably comprehensive little book on chemotherapy (the use of chemicals in the treatment of disease) Dr. Duthie has compromised so skilfully that one is hardly aware of it. The first two chapters on microbes and organic chemistry respectively serve to introduce the reader to the subject matter of the book. The explanations are so concise and readable that the non-technical reader should have no difficulty in following them: the scientist, on the other hand, will find no sins of commission and few of omission. Dr. Duthie's style is happily explanatory rather than didactic and even familiar stories such as Ehrlich's invention of Salvarsan hold the attention. The chapters on tropical diseases contain some excellent diagrams and the artist is to be congratulated on the "flow-sheet" diagrams which illustrate the life-history of the mosquito (p. 70) and the common routes of infection (p. 65). There is, perhaps, a little too much organic chemistry and too many structural formulae in these chapters, but by reading only the text and ignoring the formulae the reader is still able to get a clear idea of the nature of the problems and researches discussed. Here, in fact, is one of Dr. Duthie's most successful compromises. For the scientist not active in this particular field will find his curiosity satisfied about substances with familiar, but unhappily forgotten names. Quinine and cinchogine, mepacrine and paludrine, DDT and Gammexane are all described.

Under the title "Chemistry Conquers Bacteria" there is a well-documented account of the sulpha drugs, probably the most important chemotherapeutic agents yet invented. Here again there is plenty of technical organic chemistry but this is demanded by the very nature of the subject matter and is adequately explained.

The story of penicillin is, of course, well known, at least in outline, to most people who take an interest in science, but it is concisely retold here together with an account of the methods of manufacture. There is an excellent set of diagrams on pp. 108 and 109 which illustrate alternative large-scale methods, while the very well produced set of before-and-after photographs (plates VII and VIII) illustrate its usefulness, perhaps a little too vividly for the squeamish. The other plates showing stages in manufacture are also of a high standard.

The latter part of the book deals with the more general aspects of the subject while there is an excellent tabulated summary between pp. 150 and 151. The book ends with a glossary and index.

It is seldom that a reviewer has the opportunity to recommend a book so unreservedly to technical and non-technical readers alike; the pleasure of doing so is accordingly the greater.

R. G.

He Conquered Death. The Story of Frederick Grant Banting. By Margaret Mason Shaw. (Macmillans, Toronto and London, 1946; p. 110, 8*s.* 6*d.*)

PREDIGESTED and potted biographies of great men are a not uncommon ingredient in children's literature: this little book is something new. That the first published biography of a man like Banting should be in the form of a book for children is unusual in itself. Miss Shaw draws a portrait of Banting the man in the positive terms that children can grasp. To the adult eye he seems a little too perfect to be true, but that is readily forgivable. The technique used to put over the story of insulin is admirable. The "storyteller" is a doctor, his audience four boys. The doctor deals not only with the history of Banting's work on insulin but with the physiology of diabetes, the boys interrupting him with questions whenever he gets too technical. Interest is maintained throughout by changes of subject. In this way the reader learns of Banting's gifts as an artist, of his arduous holidays in the Arctic, of the work both before and during the second War of the Banting Institute, and of the successes of some of Banting's pupils. I can pay no greater tribute to Miss Shaw's enterprise than to express the hope that there will be more books of this type about by the time my children are old enough to read them.

R. P. H.

Records and Research in Engineering and Industrial Science. By J. Edwin Holmstrom (Chapman & Hall, London, 2nd edition, 1947; p. 366, 21*s.* net.)

SEVEN years ago the first edition of this book made its appearance and due to the exigencies of war-time publishing vanished very soon after. It is with pleasure then that the publication of the second, revised and enlarged, edition is noted. Dr. Holmstrom has gathered together in his pages a wealth of bibliographical and documentary information which is inaccessible if not unobtainable in other ways. An enthusiast in the field of gathering, classifying and collating engineering information he infuses all his readers with some of that same spirit and makes the most hard-headed of practical men realise the great utility and worth of this sometimes despised branch of systematic science.

At the same time theoretical and practical, general and detailed, he deals with all those points which are too often neglected in the applied scientist's training; how, where and when to get information and what to do to use it in the best possible manner. He starts at the beginning and indicates the bases on which all scientific and engineering information is founded, proceeds to detail indexes, libraries, abstracts, reports etc.; discusses the sorting, integration, classification and application of information, outlines the methods of expression and transmission of facts, and ends with a chapter on the technician as a person, showing how the principles laid down earlier in the book can reflect on the work of an engineer or industrial scientist. An excellent chapter on translating information from foreign languages is well worth reading. In view of the recent issue by the British Standards Institution of the engineering section of the Universal Decimal Classification, the chapter on this and similar systems of classification is peculiarly appropriate.

The original edition, appearing as it did just after the outbreak of war, necessarily contained much detailed information which was incorrect. These items have now been revised and corrected, and a total of 64 extra pages added to the volume, the bulk of this coming from an entirely new chapter on international, imperial and foreign organisations.

E. D. HART

Industrial Research 1947. Advisory editor, Dr. P. Dunsheath. (Todd Reference Books, 1947; pp. 534, 25*s.*)

WITH the appearance of the first volume last year of this reference book on industrial research its reputation was established, and this year's volume well maintains that reputation. It gives invaluable information about Government laboratories and scientific institutions in Britain and overseas, Unesco, professional and learned societies, producers' and manufacturers' organisations, university laboratories, technical colleges, etc. There is also a directory of consultants. Dr. B. J. A. Bard, head of the Industrial Research Secretariat of the F.B.I., has contributed a chapter dealing with industrial research progress in 1946-7, and this is followed by one surveying Government legislation and policy in the industrial research field. A very excellent piece of compilation is the section giving particulars about careers in professions associated with industrial research.

New Editions

WE have received review copies of the second editions of the following standard textbooks.

The Methods of Cellulose Chemistry. By Charles Doree (Chapman & Hall, London, 1947; p. 543, 42*s.*)

Introduction to Atomic Physics. By S. Tolansky. (Longmans, London, 1947; pp. 352, 15*s.*). This edition includes a special appendix on atomic energy and nuclear fission.

The Terpenes. By J. L. Simonsen. (Cambridge University Press, London, 1947; p. 479, 30*s.*)

Far and Near

The First Plutonium Pile

SUCCESSFUL operation of a new type of atomic pile which may influence the design of future experimental reactors for power was announced on August 29 by Dr. Norris E. Bradbury, Director of the Los Alamos Scientific Laboratory, which is operated by the University of California for the U.S. Atomic Energy Commission.

The new unit is the first to employ the fission of the man-made element, plutonium, instead of normal uranium and it is also the first to use fast neutrons. The heart of the fast reactor is a small vessel containing a critical mass of the nuclear explosive plutonium which emits neutrons of high energy. The high-energy or fast neutrons are caught by other atoms of plutonium before they have been slowed down by colliding with any materials except the nuclear 'fuel'. All other reactors have mixed with their nuclear 'fuel' some other substance, such as graphite, or heavy water, which serves to slow the neutrons. The Los Alamos reactor utilises no diluting material and thus shares with the atomic bomb the property of using the neutrons from fission almost as soon as they are emitted. The fast reactor's energy release proceeds at a rate which can be set easily by the operators and be kept constant.

A thick shielding wall of concrete and steel prevents the escape of the radiation. Instruments for gauging every phase of experiments with the pile are contained in a panel in a room adjoining the fast reactor.

Safe Insecticides

A NEW class of insecticides which kill pests with unusual speed but are non-poisonous to men and animals was described at the 112th national meeting of the American Chemical Society.

The new materials include a synthetic product called piperonyl cyclonene and numerous related compounds, according to a report presented by Dr. Oscar F. Hedenburg of the Mellon Institute, Pittsburgh, and Dr. Herman Wachs. Members of the piperonyl cyclonene group differ from DDT and other insecticides developed in recent years in being almost completely non-toxic to warm-blooded animals, even in massive dosages.

The German compound, called hexaethyl tetraphosphate, which was produced as an offshoot of research on war gases, is now being manufactured on a large scale in the United States and is particularly useful against certain pests which do not succumb to DDT and other insecticides, according to a paper read at the same meeting by S. A. Hall and Martin Jacobson of the U.S. Department of Agriculture's Entomology Bureau.

Electron Jubilee Celebrations

LAST month the Institute of Physics and the Physical Society in collaboration with the Institution of Electrical Engineers celebrated the Jubilee of the discovery of the electron by J. J. Thomson with a series of lectures and other functions. For the non-scientific public there was a special lecture by Sir Clifford Paterson entitled "The Electron Liberated", and illustrated by experiments and demonstrations.

Industrial organisations and Universities collaborated with the Science Museum, South Kensington, in arranging a special exhibition, which will remain open for about three months. The exhibition is designed to show the principles underlying the applications of the many devices in which the electron plays an essential part, and to help the visitor to appreciate the important part these developments play in everyday life. A handbook has been specially written by Mr. D. H. Follett, of the Science Museum; the first part is a guide to the exhibition and the second is a general account of the subjects dealt with in the various sections of the exhibition. Copies of the handbook are on sale at the exhibition, and will also be obtainable from the Institute of Physics, 47 Belgrave Square, London, S.W.1. (price 1*s.* 2*d.*, post paid).

A.Sc.W. on Atomic Control

FROM press reports of recent proceedings of the United Nations Atomic Energy Commission what has emerged most sharply has been the differences expressed in that body. A statement by the Executive Committee of the Association of Scientific Workers is at pains to stress the very considerable amount of agreement that has been reached and to suggest compromises that might lead to further progress.

Points on which agreement has been reached include: no atomic weapons should be in national hands; an international controlling authority should be set up, with its own staff chosen on international principles and with full rights to inspect all establishments concerned with producing atomic energy or its raw materials; it should have its own rules of procedure and not be subject to veto in its day-to-day functioning; it should be empowered to conduct special investigations when breaches of agreements are suspected; and it should have its own research organisation so that it can keep abreast of current developments.

There is the basis here for negotiations that could lead to full agreement; but there are also important outstanding points of disagreement. The American plan insists that all large atomic energy establishments shall be owned and managed by the international authority, but with this the U.S.S.R. does not agree. The A.Sc.W. in this case leans towards the Soviet point of view, believing that the location and building of plants should be left to the nations themselves (subject to inspection to prevent unlawful uses), but hopes that the development of international control, even in an initially imperfect form, will lead to greater mutual confidence and thence to international ownership at a later stage.

The Americans, wishing to ensure that if they cease manufacturing atomic bombs no other country can do so illicitly, insist on unlimited rights of inspection. The U.S.S.R. fears that inspection of this type might become equivalent to an elaborate system of spying. Here the A.Sc.W. supports a suggestion made by the British Atomic Scientists' Association, that on the presentation of *prima facie* evidence of breaches of the international agreement the Atomic Energy Commission should issue a search warrant, which the suspected nation would be obliged to accept, empowering inspectors to search any specific regions for illicit plant.

The Americans have proposed that the international atomic authority shall be independent of the Security Council and that the principle of the unanimity of the great powers shall not operate on it. The U.S.S.R. wishes the atomic authority to be subject to the Security Council with its established procedure. The A.Sc.W. is of the opinion that the American proposal in this case is unworkable.

The A.Sc.W. suggests that negotiations would become easier if they were linked with those on disarmament in general—for that would change the situation in which apparently only the U.S.A. has to give something away, and would make reciprocal concessions possible.

"South African Science"

THE South African Association for the Advancement of Science has started a monthly journal of about twenty quarto pages under the title *South African Science—Suid-Afrikaanse Wetenkap*. Dr. H. B. S. Cooke has been appointed Honorary Editor of the Bulletin and Dr. L. H. Wells of the Medical School, Johannesburg, and Dr. J. I. Quin of the Onderstepoort Laboratories have been made Honorary Associate Editors. The subscription rate is 15s. a year. Those interested in obtaining further particulars should write to the South African Association, P.O. Box 6894, Johannesburg.

U.S.A. Exports Radio-isotopes

AMERICA last month lifted the ban on the export of radioactive isotopes, and scientists outside the U.S.A. have already started receiving quantities of these invaluable research aids. Supply is subject to three conditions: (1) the recipients must state the purpose for which they intend to use the isotopes and agree to adhere to that purpose; (2) they must make progress reports to the U.S.A.; (3) they must open their laboratories to visiting scientists from other countries.

Science Exhibition at Oxford

THE Annual Science Exhibition of the Oxford branch of the Association of Scientific Workers is fast becoming an important event in the field of popular science. This year it was held for two days in September and attracted nearly two thousand visitors. There were sections on atomic physics, science and the public, electronic physics, chemistry, industry, health, agriculture and biology; each section contained eight or nine

exhibits, which were the joint work of technicians and research workers. It was possible to feature some of the researches that have been yielding results in Oxford in recent years, for instance, antibiotics, the travelling wave tube and nuclear magnetism. The Exhibition was designed primarily to show the public the place that science occupies in society.

Planning at Bilston

IT is pointed out to us that much credit is due to Mr. A. V. Williams, formerly Town Clerk of Bilston, for the success of the Bilston plan (*see* DISCOVERY, August 1947, "Sociological Approach to Town Planning"). Sir Charles Reilly makes the following remarks on Mr. Williams's contribution:

> "It was Mr. A. V. Williams, then Town Clerk of Bilston, now Town Clerk of Dudley, who brought, with the aid of his Council at Bilston, Professor Neurath and then myself to that town and who first translated my ideas for semi-self-contained communities built round oval village greens, centring on a club-house into the realm of fact, first at Bilston, then at Dudley. If this is a considerable step in urban and suburban planning, making for a better community life, as I believe, its existence, except on paper, is due to A. V. Williams, sociologist as well as town clerk, more than anyone else."

Animal Physiology Institute

THE Agricultural Research Council has decided to set up an Institute for the study of Animal Physiology. The director of this new institute will be Professor I. de Burgh Daly, F.R.S., Professor of Physiology in Edinburgh University, who, it is hoped, will take office early in 1948.

D.S.I.R. Open Scottish Office

THE Department of Scientific and Industrial Research has opened a Scottish Office at 18 Melville Street, Edinburgh. Dr. H. Buckley will be in charge of the office.

Atomic Energy Train Exhibition

THE travelling train exhibition on Atomic Energy organised by the Atomic Scientists' Association, with the co-operation of the Ministry of Supply, will start at the beginning of November, touring 26 towns in England, Scotland and Wales. The aim of the exhibition will be to give the public the basic facts of atomic energy and explain its implications, its destructive and constructive purposes.

Scientists will be in attendance to answer any questions and to give additional explanations. It is planned to organise at the same time Atomic Energy Weeks in each town visited, when lectures and film shows will take place. There will be, in collaboration with various local organisations, public meetings, 'brains trusts' and conducted parties for schools etc.

The exhibition opens at Chester, and then visits the following towns; Stoke-on-Trent, Manchester, Blackpool, Carlisle, Glasgow, Dundee, Leith, Edinburgh, Newcastle-on-Tyne, Middlesborough, York, Leeds, Sheffield, Derby, Coventry, Nottingham, Leicester, Birmingham, Shrewsbury, Swansea, Bristol, Cardiff, Oxford, Reading and London. It reaches the metropolis on April 9, 1948.

Enquiries should be addressed to: Press Office, Ministry of Supply, Shell Mex House, Strand, London, W.C.2. (Tel. No. Gerrard 6933, Extensions 257 and 128).

THIS MONTH'S COVER

Surface finish in ball and roller bearings is a matter of extreme importance, and for measurement to the fine degree necessary, recording equipment of extreme precision is employed. The photograph shows a research engineer in the laboratories at the Skefko Ball Bearing Works at Luton using apparatus which can measure surface finishes to one-millionth of an inch.

Pilotless Flight across Atlantic

Last month a Skymaster aircraft of the U.S. Army Air Force made the first radio-controlled flight of the Atlantic. The take-off flight and landing were all automatically controlled by a Sperry electronic automatic pilot, weighing some 800 lb, the controls being untouched by hand during the twelve hours that elapsed between the time the plane left Stephenville, Newfoundland, and the time it landed on Brize Norton Aerodrome, Oxfordshire. The existence of a British auto-pilot, the S.E.P.1, which could do the same job, is reported.

Night Sky in November

The Moon.—New moon occurs on Nov. 12d 20h 01m, U.T., and full moon on Nov. 28d 08h 45m. The following conjunctions take place:

November

6d 03h	Mars in conjunction with the moon,	Mars	4° S.
6d 07h	Saturn	Saturn	5 S.
11d 20h	Mercury	Mercury	0.03 S.
14d 01h	Jupiter	Jupiter	2 N.
14d 10h	Venus	Venus	1 N.

In addition to these conjunctions with the moon, the following conjunctions also take place:

November

9d 14h	Venus in conjunction with Jupiter,	Venus	0.9° S.
11d 18h	Mars in conjunction with Saturn,	Mars	0.9 N.

The Planets.—Mercury, in inferior conjunction on Nov. 5, becomes a morning star later and rises at 5h 40m or 1h 36m before the sun on Nov. 15, and at 6h or 1h 40m before the sun on Nov. 30, its stellar magnitude on the latter occasion being about that of a first magnitude star. It may assist in finding Mercury to remember that at the middle of the month it rises at a point on the horizon 70° from the south, and at the end of the month at a point on the horizon 65° from the south, but of course it cannot be seen until it is at some degrees above the horizon. Venus sets half an hour after the sun on Nov. 1 and a little more than an hour after the sun on Nov. 30, and can be seen very low in the western sky. Mars, in the constellation of Leo, rises at 23h 08m, 22h 52m, and 22h 25m, at the beginning, middle, and end of the month, respectively. Towards the end of November the planet is close to the bright star Regulus—the brightest star in Leo—and can be easily identified by its ruddy colour.

Jupiter sets in the early evening hours and is unobservable. Saturn rises at 23h 38m, and 21h 50m at the beginning and end of the month, respectively, and makes a very close approach to Mars on Nov. 11. At this time Mars is 123 and Saturn 854 million miles from the earth, respectively.

On Nov. 12 there will be an annular eclipse of the sun, invisible at Greenwich but visible over parts of North America, of Central America and the more northerly parts of South America, and in the North and East of the Pacific.

In the constellation of Auriga there is a beautiful bright star called Capella which cannot be easily mistaken. Soon after midnight at the end of November it is nearly overhead in our islands. Its diameter is about 12 times that of the sun, which implies that its volume is nearly 2000 times the sun's volume, and its distance from us is about 50 light-years. An interesting fact about it is that its surface temperature is 5500° C., which is nearly the same as the sun's surface temperature, and in fact Capella and the sun belong to the same class, known as the G class, the temperatures of which are in the neighbourhood of 6000° C. A little east of Capella is another bright star—Beta Aurigae—though not so bright as Capella. Both of these stars have one feature in common—each is a double star and the companions are so close to the brighter stars that they were not discovered by means of the telescope but with the spectroscope. In the case of Beta Aurigae, the companion revolves round the centre of gravity of the system in about 4 days.

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